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SEVERAL ADDITIONAL PHYCOMYCETES SUBSISTING ON NEMATODES AND AMOEBAE

CHARLES DRECHSLER¹

(WITH 4 FIGURES)

THE NEMATODE-CAPTURING PHYCOMYCETE WITH PYTHIUM-LIKE CHLAMYDOSPORES

In a brief summary published 12 years ago (7: p. 269, fig. 15C, 15D; p. 270, lines 7-19) a fungus was recorded that had been found capturing nematodes by means of adhesive material secreted by its unseptate hyphae; the same hyphae later giving rise to globose chlamydospores which with respect to their frequently intercalary position as well as with respect to size and shape strongly resembled the chlamydospores or sporangia of many species of *Pythium*, including the several species so widely familiar in causation of damping-off. The fungus soon afterwards was discussed in regard to its manner of capturing prey (8: p. 142, 143), and subsequently (11: p. 211) was mentioned as appearing, from similarities of mycelium and predaceous habit, closely related to the conidial phycomycete I then described as *Stylopaga hadra*. Its resemblance in vegetative development and predaceous habit to both *S. hadra* and *S. leiohypha* Drechsl. (12) was pointed out in a more recent paper (19: 248-249) where also

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its manner of reproduction was brought into the family Zoopagaceae through the erection of an additional genus, *Cystopage*, on an apparently closely related nematode-capturing form, *C. lateralis* Drechsl., whose consistently lateral chlamydospores differ rather markedly from those of any familiar oomycetous species. Still lacking a binomial, the *Pythium*-like fungus of more ambiguous morphology could be mentioned in a recent review only as an unnamed phycomycete (21: p. 276, 290). In supplying a name, now rather belatedly, occasion is taken to amplify the meager characterization previously given.

The fungus appears to be abundant on decaying vegetable materials in the region adjacent to Washington, D. C.; its development having been noted year after year in Petri plates of soft maize meal agar planted with leaf mold or discolored roots collected near Beltsville, Md., in Arlington, Va., and near Fairfax, Va. Since it has come to light especially often in cultures prepared during the months of April, September, and October, from freshly collected materials, there is reason to presume that in nature, as in the laboratory, it flourishes best under cool, somewhat wet conditions, and that at the higher temperatures of summer its activity declines earlier than the activity, in general, of the nematode-capturing hyphomycetes. Its hyphae, like those of other fungi of similar biological habit, do not grow out from plantings of decaying material into an underlying agar substratum until eelworms have multiplied and are infesting the culture in some number. Once they have made their appearance they extend themselves sparsely through the culture, the individual filaments pursuing courses, which if less conspicuously straightforward than those of *Cystopage lateralis*, are yet little given to pronounced deviation. As soon as they have begun pushing their way into the transparent agar, the hyphae can be observed capturing the eelworms whose presence apparently evoked their development. Before long, where suitable prey, as, for example, *Plectus parvus* Bastian, abounds, enormous numbers of animals may often be seen vainly struggling to escape, or following their disablement, undergoing expropriation of their contents (FIG. 1, A-E). Capture is effected, as in *C. lateralis*, *Stylopaga hadra*, and *S. leiohypha*, through adhesion to glutinous

material which when freshly secreted appears clear and virtually colorless but later becomes golden yellow; the change in respect to coloration being accompanied by a change from a softly plastic to a firm consistency. As in the other three nematode-capturing zoopagaceous forms and, for that matter, as also in the many nematode-capturing hyphomycetes that utilize adhesive material, the localized masses of sticky secretion can be seen only after an eelworm has been taken, and then only on the portions of hypha that are, or have been, in contact with the animal. From such experience as has been gained so far neither the present fungus nor any other fungus specially adapted for capture of nematodes would seem to secrete beforehand adhesive material in masses visible to ordinary microscopical inspection; though, as was intimated earlier (8), the violent withdrawal of eelworms when brushing against the predaceous networks or the stalked knob-cells of various nematode-capturing hyphomycetes suggests that some modification of the hyphal surface, vividly perceptible to animals threatened by it, may be present even when the microscope fails to reveal any cause for alarmed behavior. It is true that *Arthrobotrys entomopaga* Drechsl. (22), which now and then captures nematodes in some number, secretes adhesive material copiously beforehand, but there can be no question that the predaceous apparatus of this hyphomycete is primarily adapted for capture of springtails; so that the closer analogy to the trapping devices of the sundews or more especially of the carnivorous phanerogamic genera *Byblis* and *Drosophyllum* may be held to reflect the rather different requirements for capturing insect prey.

While many captured nematodes are fastened to a mycelial filament in only a single place (FIG. 1, *A, B, C, E*), some are fastened in 2 places (FIG. 1, *D*), and others in no less than 3 places. In any case when the individual captive has become quiescent, presumably from exhaustion, its integument is penetrated by an infective process extended from the hypha through the cushion of adhesive material. After the animal's protective layer has been breached, the infective process gives off several assimilative branches often hardly more than half as wide as the external filament. These branches grow lengthwise through the fleshy interior, bringing about globulose degeneration of musculature

and organs in their advance. The firm tissues of the oesophagus and valve resist destruction somewhat better than the softer parts (FIG. 1, *C, D, E*), but before long these likewise disintegrate. In a short time the globuliferous degeneration products are absorbed with such completeness that nothing of the animal remains visible except the integument, and, in male specimens, the spicula. Thereupon the assimilative branches also become evacuated, by movement of their protoplasmic contents backward into the parent hypha; their empty membranes, like the host integument, soon collapse and disappear from view, leaving only the persistent lump of yellow adhesive material, together, perhaps, with some portions of hyphal envelope, to indicate a concluded instance of predaceous action.

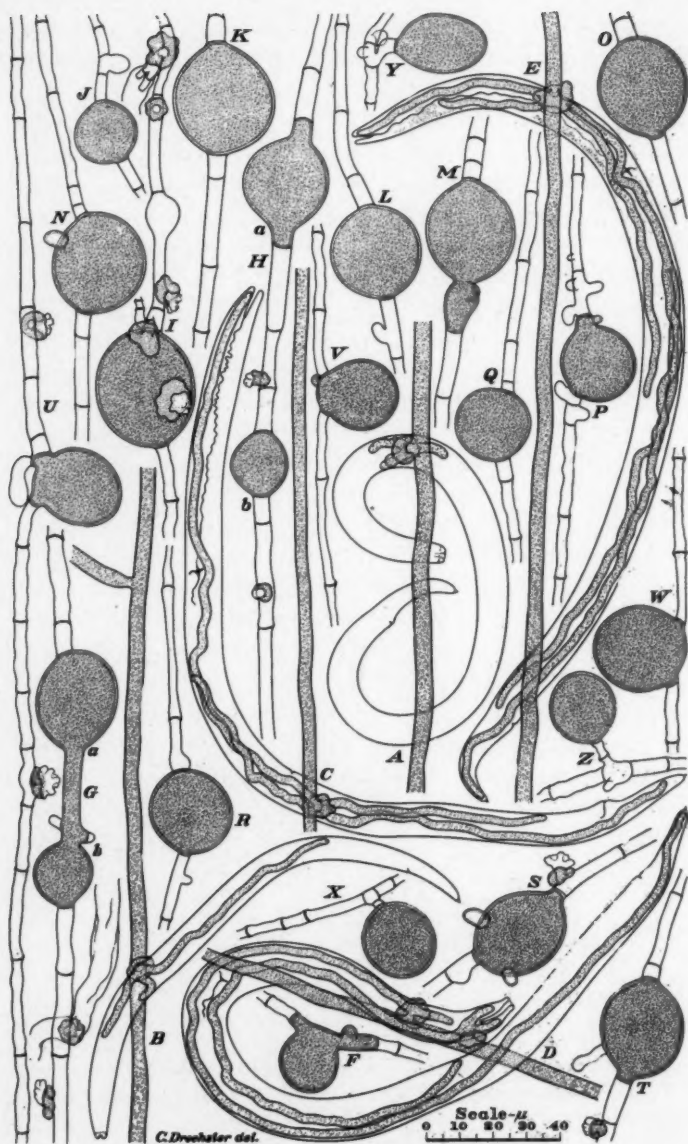
Production of chlamydospores in Petri plate cultures often begins about 8 or 10 days after vegetative development has become noticeable, and may therefore proceed simultaneously with vegetative development if the supply of living prey is replenished through active multiplication of suitable nematodes; though as a rule capture of eelworms will then have greatly diminished in frequency. Formation of a chlamydospore ordinarily is accomplished by withdrawal of protoplasmic contents from the adjacent portions of mycelial hypha; the progressive migration of granular material resulting in a succession of retaining walls spaced at intervals of 5 to 50 μ (FIG. 1, *F-Z*). While generally of subspherical shape, the chlamydospores may in their definitive condition include a short cylindrical part at either end (FIG. 1, *F*), or may consist of two globose parts connected by a living portion of outwardly unmodified hypha (FIG. 1, *G, a, b*). Aside from axial prolongations, the subspherical shape of the chlamydospores is often modified in some degree by the presence of lateral diverticulations, which frequently are found empty (FIG. 1, *N, S, T, U*), yet sometimes remain filled with protoplasm (FIG. 1, *V, P*). Occasionally a chlamydospore may bear a sigillate lump of yellow adhesive material with membranous vestiges of a centrally perforating branch, or, more rarely, may bear two such lumps (FIG. 1, *I*). Manifestly these lumps are entirely similar to those on evacuated hyphae (FIG. 1, *G, H, I, S, T, U*) and must likewise be interpreted as recording the capture and destruction

of a nematode; the predaceous action, in most instances, probably having been completed, or at least well started, before the development of the chlamydospore began.

The position of the chlamydospores relative to the hyphae bearing them, while hardly to be regarded as a feature of much fundamental importance, yet provides the most convenient diagnostic character of the fungus under consideration. In *Cystopage lateralis*, the only congeneric form known to prey on nematodes, the chlamydospores are invariably formed laterally; whereas in the present species they are more often intercalary (FIG. 1, *F-W*) than lateral (FIG. 1, *X-Z*), though lateral development is apparently never absent here, and in some cultures may even become rather frequent. With the difference in relationship to the parent hypha is associated an appreciable difference in shape; the pouch-like and lobate types of chlamydospores abundant in cultures of *C. lateralis* being only rarely approximated in the present fungus. Further, the two fungi seem to differ in geographical distribution. *C. lateralis* has been found in nearly all collections of leaf mold taken from deciduous woods in northern Wisconsin, but has not been obtained from any of the more numerous collections of leaf mold and decaying roots taken from deciduous woods near Washington, D. C., during the last ten years. The present fungus, on the other hand, has been found represented as meagerly in material from Wisconsin as it has been found represented abundantly in material originating near the District of Columbia. In naming it, however, an epithet contrasting with "lateralis" appears less disadvantageous than any term that might be suggested by the meager distributional information now available.

***Cystopage intercalaris* sp. nov.**

Mycelium sparsum; hyphis continuis, incoloratis, plerumque 3-5.5 μ crassis, saepe plus minusve recta procurentibus, vermiculos nematoideos glutino primum incolorato mox flavo tenentibus, integumentum cujusque animalis capti perforantibus, ramulos assumentes vulgo 2-3 μ crassos intus evolventibus qui carnem exhauriunt; chlamydosporis saepius intercalaribus sed quoadmodum a latere hyphae mycelii oriundis, flavidis, vulgo globosis vel elongato-ellipsoideis, plerumque 18-35 μ longis, 15-30 μ crassis.

FIG. 1. *Cystopage intercalaris*.

Vermiculos nematodeos diversos usque 500 μ longos capiens consumensque habitat in humo silvestri et radicibus putrescentibus prope Beltsville, Maryland, in Arlington, Virginia, et prope Fairfax, Virginia.

Mycelium sparse; hyphae continuous, colorless, mostly 3 to 5.5 μ wide, by means of an adhesive secretion at first colorless but later becoming golden yellow capturing nematodes, then penetrating the integument of each captive with an infective branch that gives rise within to assimilative filaments, commonly 2 to 3 μ wide, which appropriate the fleshy contents. Chlamydo-spores usually distinctly yellowish, commonly subspherical or elongate ellipsoidal, mostly 18 to 35 μ long and 15 to 30 μ in greatest width, frequently either mesially or laterally intercalary, and somewhat less often occurring laterally either from lateral development or from development in terminal or subterminal positions in short hyphal branches.

Capturing nematodes up to 500 μ in length, referable to *Acrobelloides*, *Cephalobus*, *Plectus*, *Rhabditis*, and other genera, it occurs abundantly in leaf mold and decaying roots near Beltsville, Md., near Fairfax, Va., and in Arlington, Va.

A SEXUAL STAGE POSSIBLY BELONGING TO
CYSTOPAGE INTERCALARIS

In an earlier account (11: p. 211, lines 11-18) I made mention of a nematode-capturing phycomycete that had been observed in its sexual reproductive stage. The fungus to which reference was made came to light early in January, 1934, in a maize-meal-agar culture planted 35 days before with several pinches of leaf mold originating from deciduous woods in Arlington, Va. Although predaceous activity had virtually come to an end, apparently because of the small number and sluggish behavior of the surviving nematodes, numerous empty integuments, many of them with an outline and with annulations suggestive of *Acrobelloides bütschlii* (DeMan) Thorne, were found attached to sigillate masses of yellow adhesive material that studded the unseptate, sparsely branched mycelial filaments (FIG. 2, A). Each sigillate mass showed clearly a central perforation, and often in addition, membranous vestiges of a haustorial system; wherefore it was evident that numerous eelworms had somewhat earlier been captured and depleted of their fleshy contents.

The entire mycelium of the fungus was looked over carefully for conidiophores, conidia, and chlamydospores, but no asexual reproductive structures could be discovered anywhere. As the mycelial hyphae measured 2.5 to 4 μ in width, they would seem to have been slightly coarser than those of *Stylopage leiohypha*, and slightly more delicate than those of *S. hadra*, *Cystopage lateralis*, or *C. intercalaris*; the dimensional difference in either direction being, however, too small to permit, in itself, recognition of a separate species. Identity with *C. lateralis* appears almost certainly excluded, since that form has not hitherto been seen in cultures prepared with leaf mold from the region surrounding Washington, D. C. Absence of bulbous hyphal protuberances at the places where nematodes were attached cannot be considered to exclude possible identity with *S. hadra*, for when developing on soft agar substrata *S. hadra* often fails to produce such protuberances. Accordingly the predaceous mycelium may belong to *S. hadra*, or with perhaps slightly greater probability to either *S. leiohypha* or *C. intercalaris*; or, again, it may represent a species whose asexual reproductive phase has as yet not come under observation.

Its sexual reproduction, at all events, yielded zygospores in moderate quantity. The development of these bodies occurred only where two main mycelial filaments crossed or came close together (FIG. 2, A-C: *a, b*). Paired zygophoric branches invariably arose from separate filaments; their growth taking place with abrupt changes in direction (FIG. 2, A), together sometimes with meager branching and haphazard intrication (FIG. 2, B, *c, d*). Now and then the paired branches became more pronouncedly intricated by winding helically about each other (FIG. 2, C). After the sexual branches had united apically, the globose zygosporangium sometimes grew out from near the union (FIG. 2, B, *c*), but no less often it was formed on a stalk, about 5 μ long, arising from near the union (FIG. 2, A; B, *d*); and in other instances it developed laterally on one of the zygophoric branches, as much as 15 μ below the fused tip (FIG. 2, C). When the zygosporangium had attained a diameter of 14 to 16 μ , its growth ceased, and its spherical membrane became thickened unevenly in being transformed into a somewhat crustose, externally corru-

gated yellow envelope (FIG. 2, *D*). Directly under this envelope the zygosporic wall was then laid down as a colorless layer with a uniform thickness of about $1\ \mu$. The contents of the more mature zygosporic cells consisted in large part of coarsely and uniformly granular material, within which were discernible from 5 to 10 homogeneous reserve globules, mostly 2.5 to $3.5\ \mu$ in diameter, together with at least one refringent body (FIG. 2, *D*).

THE SEXUAL STAGE OF COCHLONEMA PUMILUM

In a maize meal-agar plate culture that after being permeated with *Pythium* mycelium had been further planted with a small quantity of leaf mold taken from deciduous woods near Fairfax, Va., on November 10, 1942, there was observed 28 days later some development of the small endoparasite I described in a previous paper (17) as *Cochlonema pumilum*. The fungus subsisted evidently on the same protozoan species that it had attacked in the earlier material; the identity of the testaceous host animal being especially clear since more than a few of the parasitized individuals measured only 20 to $25\ \mu$ in length (FIG. 3, *A, B*), and thus shared the small dimensions noted in my earlier account. However, most of the individual rhizopods were of greater size, measuring commonly from 30 to $38\ \mu$ in length and from 18 to $22\ \mu$ in width (FIG. 3, *C-M*), and therefore offered better agreement with Wailes' (35) description of *Euglypha laevis* (Ehrenb.) Perty, the species to which the host animal was referred. Despite the frequent presence of plural conidia within them (FIG. 3, *C*), the larger infected animals, like the smaller ones, were never seen to contain more than a single thallus; so that the thalli here attained greater dimensions and naturally, when asexual reproduction supervened, gave rise to correspondingly more abundant conidial apparatus. Thus, in many instances, 3 or 4 conidial chains, each about $500\ \mu$ long, were found arising from near the mouth of the empty host testa; the total number of conidia then produced being about 3 or 4 times greater than had been observed in the earlier material where only small animals were present.

Although the larger number of thalli in the culture expended their protoplasmic materials entirely in giving rise to conidial

apparatus, sexual reproduction by development of zygospores was, nevertheless, rather frequent, being displayed by relatively small thalli within small animals (FIG. 3, *B*) as well as by the more robust thalli within the larger animals (FIG. 3, *D-M*). If occasionally—perhaps in one among fifteen or twenty instances—a thallus showed evidence of having given rise to some conidia before initiating development of a zygospore, it was yet much more usual for the individual thallus either to form conidial apparatus exclusively, or to devote all its contents to the production of a single zygospore. The earlier stages of sexual reproduction never came under observation, nor did the sexual apparatus whose development had begun show any further development in any of the several 8-hour periods during which it was studied under the microscope. This persistent inactivity has meaning in itself, since, in general, sexual development among the Zoopagaceae is not, as with species of *Pythium* and *Phytophthora*, for example, adversely affected by the environal conditions attending microscopic inspection, but on the contrary, is often encouraged by them. From analogy with the congeneric form I described as *Cochlonema symplocum* (19) there is reason to presume that sexual development was at a standstill during the periods of observation because of unsuitably high temperatures—75° to 85°C.—maintained in the laboratory during working days in winter, and that it was initiated and could proceed only at the lower temperatures intervening on week-ends and during periods of unusually cold weather.

Whatever may be the environal conditions governing its development, the globose zygosporangium of *Cochlonema pumilum* is always formed in a position approximately between the two ends of the thallus. As the thallus is strongly curved, its ends are usually close together when definitive size is attained; so that from spatial necessities, the globose cell often comes to extend backward toward the fundus of the animal host (FIG. 3, *D, F, L*), or to lie for the most part to one side of the plane of the thallus (FIG. 3, *E, J*), or to jut forward toward the mouth of the animal host (FIG. 3, *B*). In favorable instances where a profile view is afforded of relationship between thallus and zygosporangium, a structural connection is sometimes discernible between the

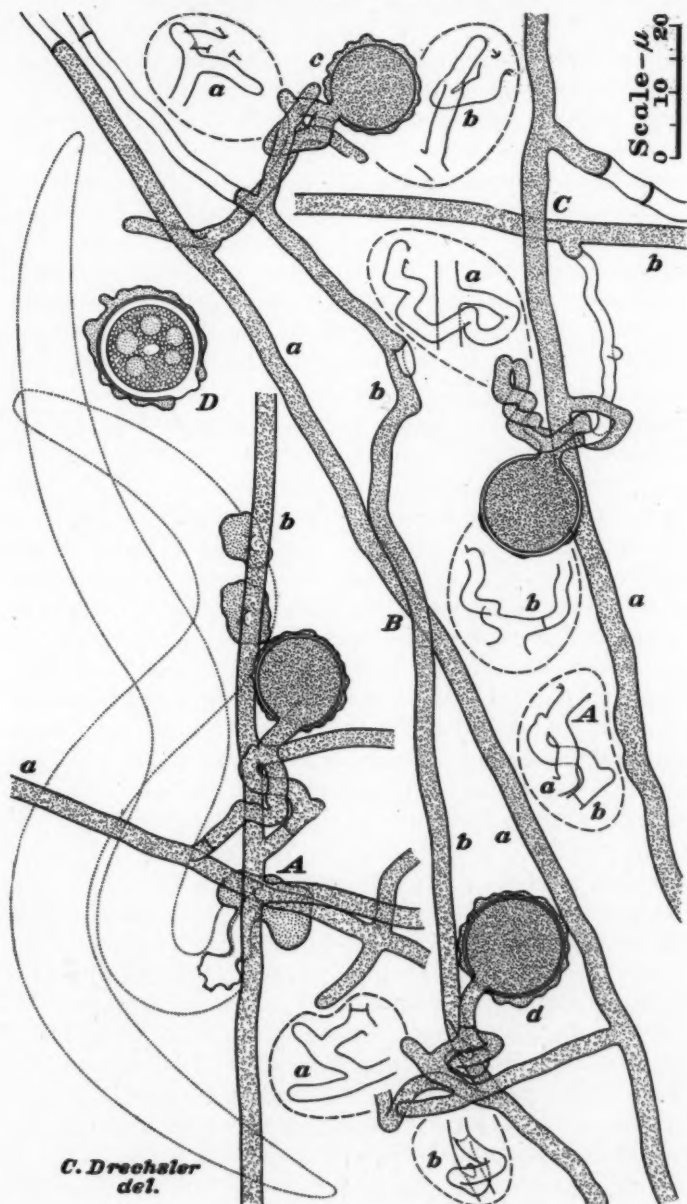


FIG. 2. Sexual stage of a nematode-capturing fungus belonging in the Zoopagaceae.

proximal end of the thallus and the zygosporangium (FIG. 3, *D, K*), while at other times the distal end of the thallus appears united to the zygosporangium (FIG. 3, *B, F*), and somewhat rarely both ends of the thallus seem joined to the zygosporangium (FIG. 3, *G*). Although now and then (FIG. 3, *K*) the zygosporangium shows such broad attachment to the thallus that hardly any modification in the thalldic extremity would need to be assumed, more often a narrowing of the thalldic extremity suggests that a short prolongation, interpretable as a zygophoric branch, must have been put forth to initiate sexual development (FIG. 3, *D, E, F*).

In the production of a zygospore, just as in the production of conidia, the distal portion of the thallus is always evacuated first; its membrane often being found empty and somewhat collapsed at a stage when the proximal portion is still, through increasing vacuolization, contributing its protoplasm to the growing zygosporangium (FIG. 3, *E, F, G, K*). Even after it has lost all its contents, the proximal part retains its original outline rather well, giving the impression that it is surrounded by a sturdier wall (FIG. 3, *D, H, I, J*) than the distal part. Where, as is often true, the empty thalldic envelope contains only the one partition that separates the collapsed distal part from the unshrunk proximal part (FIG. 3, *B, J, L, M*), the whole apparatus usually offers an appearance strongly suggestive of a developmental sequence as follows: (1) division of the thallus into two gametangia; (2) conjugation between two short zygophoric prolongations put forth, respectively, from the proximal end of the proximal gametangium and the distal end of the distal gametangium; and (3) production of a zygospore at or near the place of conjugation. As nothing has been observed directly at variance with such a developmental sequence, it is held to prevail generally in the species; though, owing mainly to optical difficulties usual in parasitized testaceous rhizopods, many specimens are so ambiguous in what they reveal that if they were considered individually other interpretations might be entertained.

Thus, in the numerous examples where the relationship of the zygosporangium to the thallus is not shown in profile, and more especially in the many examples where one or both ends of the

thallus lie concealed under the zygosporangium, double attachment of the globose body is neither visible nor directly surmisable; so that development of an azygospore rather than of a zygosporangium might be in progress. However, if azygospore formation were at all frequent, occasional specimens should reveal one end of the thallus to be free and clearly separated from the globose body—a condition that has not been observed so far. Then, too, where double attachment of the globose body to the thallus cannot be made out, a possibility exists that a supernumerary conidium, perhaps concealed under the globose body itself, may have taken part in the antecedent sexual union after the manner of conidia in the allied forms I have described as *Stylopaga cephalote* (15) and *Acaulopaga marantica* (16). If such conidium-thallus conjugation prevailed clear instances of it should now and then be discernible; but no clear instances have come to light, and although in one case the zygosporangium appeared intercalated between the thallus and an empty conidial envelope (FIG. 3, K), the relationship of parts found here was best explained on the assumption that the empty conidium was the spore-parent of the thallus, and that it came into its unusually distant position through the development of the zygosporangium at the juncture of its germ tube with the thallus. Again, some little ambiguity not, however, attributable to optical difficulties arises frequently in specimens where the thallus, after yielding its contents to the zygosporangium, shows two (FIG. 3, I) or even three (FIG. 3, D, H) transverse partitions; the plural cross-walls, of course, making for an appearance less suggestive of division into two gametangia than is offered by specimens with only one cross-wall. Since the extra partitions are manifestly laid down as retaining walls in the progressive evacuation more particularly of the longer proximal thalldic segment that presumably constitutes the proximal gametangium, they can hardly be considered to have much special significance.

Once the thallus has been completely evacuated, a thick, distinctly yellowish zygosporangial wall with a scalloped outer contour is laid down close under the colorless and slightly collapsed zygosporangial envelope (FIG. 3, H, I, J). This wall surrounds rather coarsely granular protoplasm within which, at full maturity, one

or two reserve globules and one or two smaller refringent bodies are often somewhat indistinctly discernible (FIG. 3, B, L, M). As only a single thallus develops within the individual animal host, and as in instances of sexual development the entire protoplasmic contents of the thallus are usually given to the single zygosporangium, it is not surprising that the dimensions of the zygosporangium and zygospore, like those of the thallus, are governed mainly by the dimensions of the infected protozoan. For a fungus which in its vegetative body, as also in its asexual reproductive structures, is rather small in comparison with allied forms, the sexual structure may be considered somewhat large—the diameter of the zygosporangium varying mostly from 9 to 15 μ , and that of the zygospore from 8 to 14 μ . The zygospore wall was found ranging from .8 to 2.2 μ in thickness, while the protoplast surrounded by it varied from 5.5 to 10 μ in diameter.

A BRANCHED COCHLONEMA PARASITIC ON A
TESTACEOUS PROTOZOAN

A maize-meal-agar plate culture that after being permeated with *Pythium* mycelium had been further planted on Jan. 20, 1937, with leaf mold newly collected from deciduous woods in Arlington, Va., revealed when examined 3 months later about 50 specimens of a testaceous rhizopod from each of which ascended a few chains of cylindrical conidia generally similar to the conidial chains of *Cochlonema pumilum* and of the congeneric form I described earlier as *C. cylindricum* (14). Although no living specimen of the animal could be found, the well preserved testae (FIG. 3, N, O) were without much difficulty referred to *Sphenoderia dentata* Penard (28)—the same species, therefore, that later (17) was observed parasitized by my *C. fusisporum* and my *Pedilospora dactylopaga*. Within each testa was seen an empty convoluted thallus differing from the thalli of *C. pumilum* and *C. cylindricum* in being consistently branched. The branching, if mainly of the dichotomous type, was much less regularly dichotomous than is usual in the genera *Cochlonema* and *Endocochlus*. In most instances a strongly curved hyphal trunk was usually recognizable, which from a position often somewhat closer to its base than to its tip gave off monopodially

a short stout branch that at once broadened into 2 lobes (FIG. 3, *N*) or divided dichotomously into 2 short arms. In addition, the hyphal trunk frequently bore a short stout branch near its distal end (FIG. 3, *N*).

The empty thalli contained usually from 2 to 4 cross-walls, which manifestly had been laid down as retaining walls during the progressive evacuation of protoplasm by way of the single reproductive filament. This filament, as in all related species, followed a somewhat irregular course through the mouth of the animal, to give rise externally to the several conidial chains whereby the presence of the parasite had been betrayed. When mounted for examination under a cover glass, the chains crumbled into their component spores. These spores (FIG. 3, *P*) were found to be slightly wider than those of *Cochlonema cylindricum*, and in more noticeable measure wider than the similarly cylindrical spores of *C. pumilum*.

As the fungus seems rather markedly distinguished from its two most closely related congeners by the character of its thallus, it is described under a specific name meaning "branched."

***Cochlonema ozotum* sp. nov.**

Hyphae alitae incoloratae, saepius 40–45 μ longae, 6–7 μ crassae, axe plerumque semel convolutae, vulgo in medio et prope apicem ramis simplicibus vel bifidatis vel bifurcis praeditae, ex basi per os animalis hypham genitabilem circa 1.5 μ crassam proferentes quae 2–3 catenulas conidiorum 300–750 μ longas profert; conidiis incoloratis, cylindraceis, utrimque leviter rotundatis, vulgo 4.6–8 μ longis, 1.3–1.5 μ crassis.

Sphenoderiam dentatam interficiens habitat in humo silvestri in Arlington, Virginia.

Vegetative hyphae colorless, often 40 to 45 μ long, 6 to 7 μ wide, with respect to their main axis circularly convolved in one turn, provided with branches near the apex and also in a position nearly midway between base and apex, the branches whether simple or bifid or forked being short and stout; each vegetative hypha extending from its base and through the mouth of the animal host a colorless reproductive hypha, about 1.5 μ wide, which sends up usually 2 or 3 colorless hyphae 300 to 750 μ long to be transformed into chains of closely arranged conidia; these conidia of cylindrical shape, with slightly convex ends, colorless, measuring mostly 4.6 to 8 μ in length and 1.3 to 1.5 μ in width.

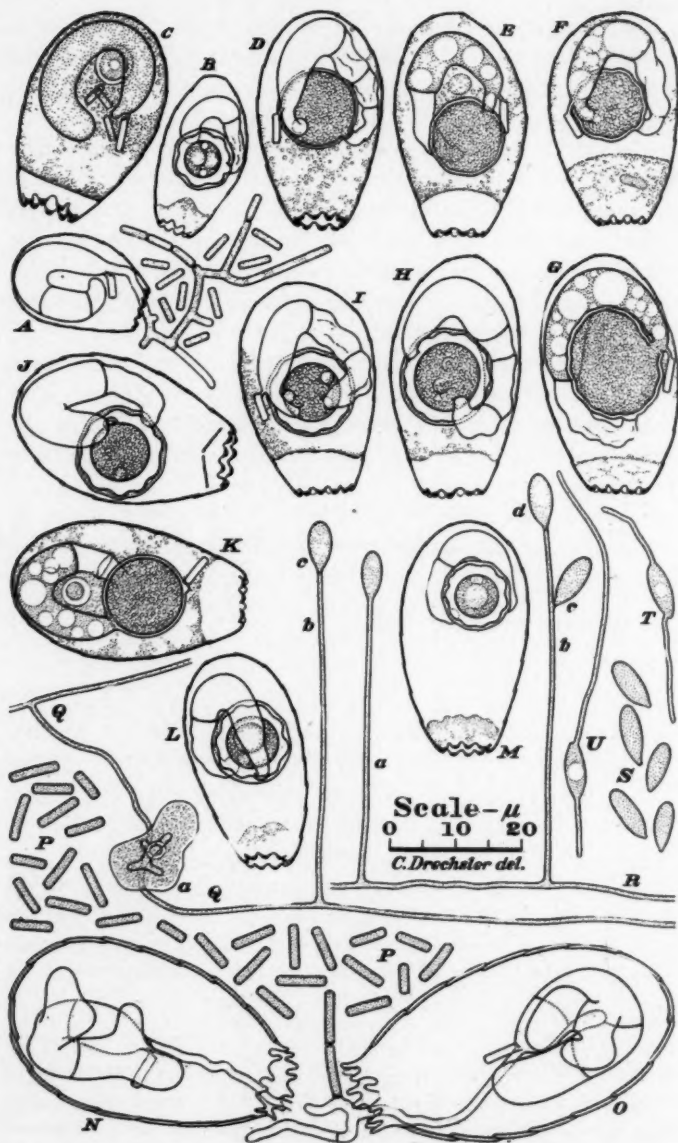


FIG. 3. A-M, *Cochlonema pumilum*; N-P, *Cochlonema ozotum*;
Q-U, *Stylopaga minutula*.

Destructive to *Sphenoderia dentata* it occurs in leaf mold in Arlington, Va.

A MINUTE SPECIES OF STYLOPAGE WITH PLUMP CONIDIA

A maize-meal-agar plate culture that after being permeated with *Pythium* mycelium had been further planted on Dec. 14, 1936, with leaf mold newly collected from deciduous woods in Arlington, Va., revealed on examination 17 days later some development of a sparse mycelium composed of very delicate hyphae (FIG. 3, Q, R) along which minute *Amoebae* (FIG. 3, Q, a) were held attached by means of yellow adhesive material. The captured animals, mostly 7 to 15 μ wide when drawn into a rounded form, contained in their colorless protoplasm a single subspherical nucleus, about 2.5 μ in diameter, wherein was visible a slightly darker globose part approximately 1.8 μ in diameter. A dichotomous haustorium with noticeably swollen, digitate assimilative branches was extended into each captive. After it had taken up the cell contents of the prey, the haustorium in turn became evacuated, through withdrawal of its protoplasm backward into the parent hypha; whereupon its empty membrane, as also the collapsed protozoan integument, soon disappeared from view.

The fungus displayed meager asexual reproduction in sending up sparsely scattered delicate conidiophores from hyphae prostrate on the substratum. These conidiophores (FIG. 3, Q, b; R, a) were often found bearing only a single conidium of elongate obovate shape (FIG. 3, Q, c), but frequently, too, after having produced one conidium they resumed growth to produce another on the new apex (FIG. 3, R, b, c, d). When conidia became detached (FIG. 3, S) and fell on the moist agar substratum, they germinated readily; in most instances they extended a delicate germ tube from each end (FIG. 3, T, U).

With respect to its generally minute dimensions the fungus shows close resemblance to the delicate congeneric species I described earlier as *Stylopage lepte* (10). Its conidia, however, are conspicuously shorter and broader than those of *S. lepte*; their shape being suggestive rather of *S. hadra* and *S. leiophya*. In

comparison, more especially, with these two robust forms the fungus appears well deserving of the name here applied to it.

***Stylopaga minutula* sp. nov.**

Mycelium sparsum; hyphis sterilibus continuis, incoloratis, parce ramosis, vulgo $.6-.9\ \mu$ crassis, ad animalia minuta inhaerentibus, pelliculam cujusque capti perforantibus, haustorium intus evolventibus quod carmen exhaurit; haustorio basi semel vel bis dichotomo, ita 2-4 ramulos $1-1.3\ \mu$ crassos ferente; hyphis fertilibus continuis, erectis, incoloratis, saepe $40-60\ \mu$ altis, $.6-.9\ \mu$ crassis, uno conidio genito saepe repullulantibus et aliud conidium gerentibus; conidiis incoloratis, ellipsoideis vel elongato-obovoideis, basi paulo acutis, $7.5-9\ \mu$ longis, $2.6-3.6\ \mu$ crassos.

Amoebas plerumque $7-15\ \mu$ latas capiens consumensque habitat in humo silvestri in Arlington, Virginia.

Mycelium sparse; vegetative hyphae continuous, colorless, filiform, sparingly branched, commonly $.6$ to $.9\ \mu$ wide, adhering to minute animals, perforating the pellicle of each captive and intruding a haustorium which bifurcates once or twice near its base to terminate in 2 to 4 short digitate assimilative branches 1 to $1.3\ \mu$ wide. Conidiophores continuous, colorless, erect, often 40 to $60\ \mu$ long and $.6$ to $.9\ \mu$ wide, after producing a first conidium terminally often elongating to bear a second one; conidia unseptate, colorless, ellipsoidal or elongate obovoid, often slightly pointed at the base, commonly measuring 7.5 to $9\ \mu$ in length and 2.6 to $3.6\ \mu$ in width.

Capturing and consuming *Amoebae* mostly 7 to $15\ \mu$ wide it occurs in leaf mold in Arlington, Va.

A SPECIES OF ACAULOPAGE WITH APPENDAGED
DICHOTOMOUS CONIDIA

Several maize-meal-agar plate cultures that were started with decaying pieces of waterlily (*Nymphaea odorata* Ait. and *N. tuberosa* Paine) leaves collected near Butternut, Wis., on July 12, 1935, permitted abundant development of a zoopagaceous fungus resembling in varying degree the congeneric forms I have described under the binomials *Acaulopage macrospora*, *A. ceratospora*, and *A. tetraceros* (10). On its sparingly branched mycelium (FIG. 4, A-E) *Amoebae* from 5 to $20\ \mu$ in diameter were found attached by means of yellow adhesive material. The smallest of the captured animals were seen invaded usually by a single assimilative branch, slightly narrower than the parent filament (FIG. 4, A, a, c; B). In animals of somewhat greater

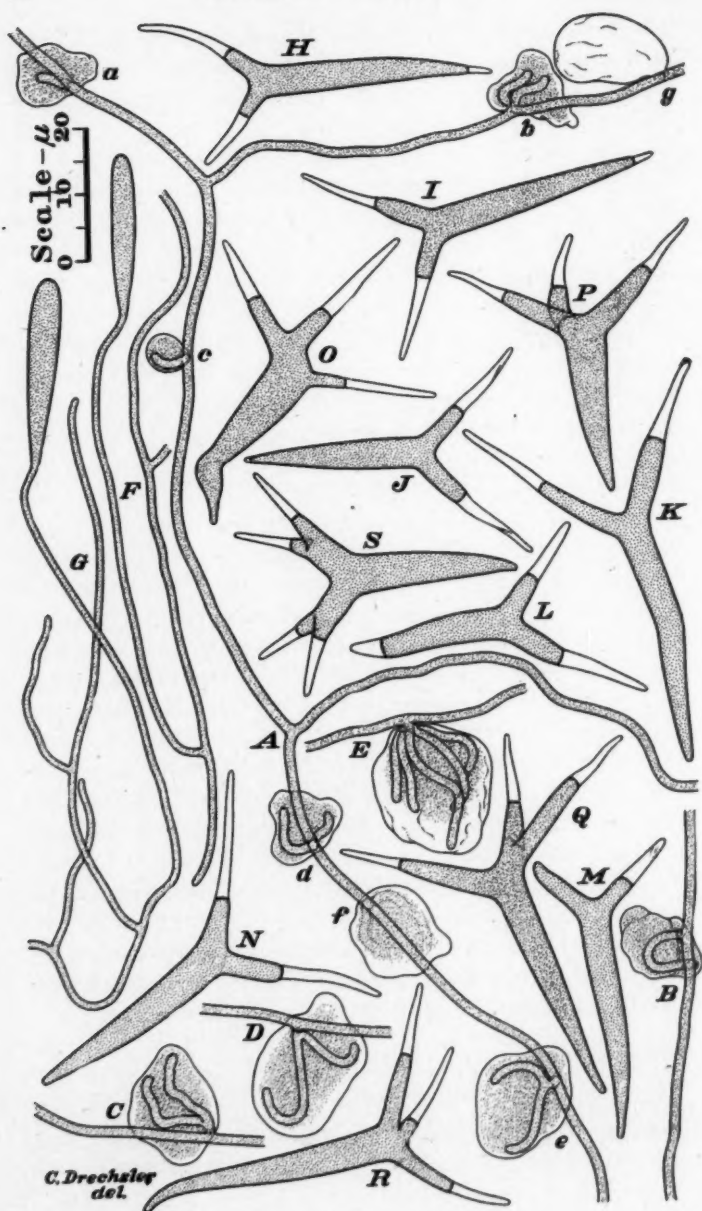
dimensions the infective process, after penetrating the integument, would often divide into 2 assimilative branches (FIG. 4, *A, b, d, e, f; C; D*), while in the largest prey that came under observation the sarcodae was permeated by a bush-like haustorium with as many as 5 branches (FIG. 4, *E*).

Thus nourished on *Amoebae*, apparently to the exclusion of other sources of food, the fungus gave rise to conidia on hyphae (FIG. 4, *F, G*) that seemed to be narrower and to ramify somewhat more freely than the predaceous filaments. As these hyphae often revealed distally a rather abrupt curvature, not unlike the curvature familiar in fertile hyphae of *Acaulopage tetraceros*, there was reason to suspect that the conidia formed terminally on them should normally have stood erect. However, in the presence of nematodes and mites, even the conidia whose unbranched clavate form betokened an early stage of development (FIG. 4, *F, G*) were mostly found prostrate on the substratum. During their later stages of growth the conidia would bifurcate distally at an angle usually approximating a right angle (FIG. 4, *H-N*); the primary bifurcation often being followed by a secondary bifurcation in one of the two divergent arms (FIG. 4, *O-R*), and occasionally by bifurcation in both arms (FIG. 4, *S*). When branching was concluded the terminal prongs, whether 2, 3, or 4 in number, were partly emptied by retraction of protoplasm, the emptied part of each prong persisting as a membranous appendage. Now and then a terminal prong, especially if undersized, retained its contents throughout (FIG. 4, *M*), but on the other hand some conidia became emptied not only distally in their prongs, but also in lesser measure, proximally through withdrawal of contents from a small conical part at the base (FIG. 4, *H, I, J, L*).

An epithet having reference to the characteristic branching of its conidia may serve in distinguishing the fungus from the several appendaged species most closely related to it.

***Acaulopage dichotoma* sp. nov.**

Mycelium sparsum, hyphis sterilibus continuis, incoloratis, parce ramosis, 1.3-1.6 μ crassis, ad animalia minuta inhaerentibus, pelliculam cujusque capti perforantibus, haustorium intus evolventibus quod protoplasma exhaurit; haustorio nunc simplici nunc ad instar arbusculae ex 2-5 ramulis assumentibus

FIG. 4. *Acaulopage dichotoma*.

5–25 μ longis 1.2 μ crassis constante. Hyphae fertiles continuae, incoloratae, mediocriter ramosae, vulgo circa 1 μ crassae, apice conidia singulatim gignentis; conidiis incoloratis, plerumque semel vel bis bifurcis, itaque vulgo ypsiliformibus vel tricornibus vel quadridentibus, trunco eorum inversum conico, saepe 25–40 μ longo, sursum 4.5–7 μ crasso quandoque in parte infima 1–5 μ longa vacuo, ramis eorum cornuatis divaricatis, 10–30 μ longis, deorsum 2–5 μ crassis primum protoplasmatis omnino repletis mox in parte supera 5–20 μ longa fere inanibus.

Amoebas 5–20 μ latas capiens consumensque habitat in foliis putrescentibus Nymphaeae odoratae et Nymphaeae tuberosae prope Butternut, Wisconsin.

Mycelium sparse; vegetative hyphae continuous, colorless, sparingly branched, 1.3 to 1.6 μ wide, capturing small animals by means of yellow adhesive material, perforating the pellicle of each captive and intruding a haustorium which may consist of a simple branch or of 2 to 5 branches, 5 to 25 μ long, about 1.2 μ wide, in bush-like arrangement. Conidiophorous hyphae continuous, colorless, moderately branched, usually about 1 μ wide, producing conidia singly at the tip. Conidia colorless, mostly branched dichotomously once or twice to terminate in 2, 3, or 4 tapering divergent prongs; the main axial part of the spore obconical, often 25 to 40 μ long, 4.5 to 7 μ wide distally, sometimes empty at the base for a distance of 1 to 5 μ ; the prongs mostly 10 to 30 μ long, 2 to 5 μ wide proximally, at first filled with protoplasm throughout but nearly always soon becoming empty distally for a distance of 5 to 20 μ .

Capturing and consuming *Amoebae* 5 to 20 μ wide it occurs in decaying leaves of *Nymphaea odorata* and *Nymphaea tuberosa* near Butternut, Wis.

TAXONOMIC CONSIDERATIONS RELATING MORE ESPECIALLY TO
CYSTOPAGE INTERCALARIS AND ZOOPHAGUS
INSIDIANS SOMMERSTORFF

Although at first sight such types of conidial apparatus as are produced by *Cochlonema ozotum* and *Stylopaga minutula* look commonplace and generally insignificant, they nevertheless prove to be unusual degree adequate for taxonomic purposes once they are known to be associated with a thallus or mycelium in which cross-walls are never laid down as partitions between adjacent living vegetative cells. Unfortunately the intercalary and frequently intramatrix chlamydospores of *Cystopage intercalaris* have far less distinctiveness, since resting bodies not greatly different from them are formed in various species of Oomycetes

and Zygomycetes. In particular, as has been noted, the chlamydospores of *C. intercalaris* strikingly resemble the conidia of some widely familiar species of *Pythium*. When they are compared, for example, with the conidia of *P. ultimum* Trow, a species often occurring as causal agent of root rot in the same vegetable materials as *C. intercalaris*, a close similarity is revealed with respect to shape, to size, to manner of attachment, to texture of the densely granular porridge-like protoplasmic contents, and to mode of germination by production of vegetative hyphae. While such correspondence in structural features might, by itself, have only rather slight descriptive interest, it becomes deserving of more attention from the fact that the rotifer-capturing *Zoophagus insidians* Somm., concerning which an unusually copious literature is available, has for the most part been treated, because of reported similarity in zoospore development, as being either closely related to *Pythium* (31) or as belonging in *Pythium* (23). Under the circumstances a suspicion could naturally arise that the chlamydospores of *C. intercalaris*, like the conidia of *P. ultimum*, might well be homologous with the globose zoosporangia of such species of *Pythium* as *P. Debaryanum* Hesse, and that, consequently, the fungus producing them might perhaps belong in the Pythiaceae rather than in the Zoopagaceae. The features suggestive of relationship in the Pythiaceae need to be examined in conjunction with developmental features ascribed to *S. insidians* that would seem to reveal more credible homologies with typical conidium-producing members of the Zoopagaceae.

Sommerstorff's (29) only observations possibly relating to reproduction of the predaceous fungus described by him were made on a single specimen of rotifer whose unattached dead body he found occupied by evacuated hyphae from which extended eruptive branches, open at the tip. Lying near this dead animal were seen numerous empty globose cysts, about $10\ \mu$ in diameter, and also a clustered aggregation of approximately 8 zoospore-like amoeboid cells. After some rotational and trembling movements these cells came to rest, rounded up, and encysted. On the following morning only empty envelopes remained where the cysts had been, the protoplasts evidently having escaped following extension of a short germ tube. Sommerstorff regarded this

isolated instance of zoospore formation insufficient for any statement regarding the systematic position of his fungus, and merely ventured the opinion that since he was dealing with a phycomycete of aquatic habit propagation by zoospores, as in the Saprolegniales, was not improbable. The sequence of conditions described by him would, indeed, seem to correspond better to zoospore development in the Saprolegniaceae than to zoospore development in the Pythiaceae. At all events the free unattached condition of the dead rotifer appears less indicative of destruction by a fungus given habitually to a predaceous mode of attack than to destruction by a fungus which either is addicted exclusively, like *Hydatinophagus Apsteinii* Valk. (32, 33), to attacking rotifers in some usual parasitic manner, or, like *Sommerstorffia spinosa* Arn. (2), displays both ordinary parasitic attack by means of zoospores and predaceous attack through capture by means of adhesive organs. The meager persuasiveness of Sommerstorff's taxonomic comment was abated further by Mirande's (27) report that though several times he found similar cysts on rotifers attacked by *Zoophagus insidians*, closer examination always showed them to represent a superadded chytrid.

In Gicklhorn's (24) account *Zoophagus insidians* is set forth as giving rise within the host animal to large sporangia, spherical in shape or often protruding distally, each delimited at the base by a thick septum; the sporangial contents, consisting of numerous immotile individualized zoospores imbedded in slime, reaching the exterior after rupture of the distal protrusion; the slime thereupon swelling rapidly, and the zoospores escaping as laterally biciliate motile swimmers. From the magnification indicated for the figures illustrating them, the zoospores would appear to measure only about $2.5\ \mu$ in diameter. The small size of these bodies, their very distinct individualization within the sporangium, and their emission in a matrix of slime, are features unparalleled in *Pythium*; yet Gicklhorn assigned the fungus to a position within the Pythiaceae close to that genus. He described a further type of asexual reproduction, wherein hyphae, 5 to $10\ \mu$ wide, after growing out of the animal abstrict terminally a number of globose conidia, about $15\ \mu$ in diameter, which collect in a

botryose or capitate cluster, eventually to fall off and to germinate by producing individually a predaceous hypha.

The sporulation that Gicklhorn took for conidial development was interpreted by Arnaudow (3) as more probably representing zoospore production of the same type he himself found in *Zoophagus insidians* (1). In this type of zoospore production, we are told, development follows the course characteristic of *Pythium*, but after the laterally biciliate zoospores, about $10\ \mu$ wide, have come to rest and rounded up they escape from the cyst envelope and again swim about as laterally biciliate swimmers, to encyst, eventually, a second time. This iterant swarming Arnaudow regarded as diplanetism of a sort not known, as far as he could ascertain, among other fungi; wherefore he concluded that the zoosporangia in question could not belong to some other aquatic fungus, were the possibility to be considered that alien phycomycetes might occur within captured animals in the role of table companions. Now, the repetitional development which Arnaudow held to be unknown elsewhere had in fact been adequately set forth 14 years earlier in Butler's (4) original description of *P. diacarpum*. Later, quite similar development was reported as occurring also in *P. Butleri* Subr. (5), in *P. dissotocum* Drechsl. (6, 18), in *P. adhaerens* Sparrow (30), in *P. angustatum* Sparrow (30), and in *P. epigynum* Höhnk (25). The zoosporangial stage observed by Arnaudow would seem, therefore, all the more certainly referable to the Pythiaceae; but, on the other hand, this stage can no longer be held necessarily connected with *Z. insidians* on the ground that it is absent elsewhere. Increased significance might consequently be read into Arnaudow's admission that with the cultural methods he employed his demonstration of connection between the observed zoosporangia and *Z. insidians* was not to be regarded as complete (nicht als lückenlos). The uncertainty expressed in this admission was, however, strongly disclaimed by Valkanow (34) who on encountering *Z. insidians* three times in his freshwater aquaria made observations which, we are told, not only confirmed Arnaudow's description of sporangial structure but also uncovered in stained preparations a very clearly visible connection between the mycelium and the evacuation tube of the sporangium. From a conviction, apparently,

that the number of swimming stages passed through by zoospores after their individualization is here of more moment taxonomically than the condition in which the sporangial contents are discharged, Valkanow referred the fungus to a position in the Saprolegniaceae near the three *Aphanomyces*-like genera *Synchaetophagus*, *Hydatinophagus*, and *Sommerstorffia*.

Whatever doubts Arnaudow may have had concerning the reality of zoospore development in *Zoophagus insidians* assuredly did not apply to a second type of asexual reproduction described by him, wherein a mycelial filament, through terminal budding, would give rise, following repeated subapical elongation, to a succession of eelworm-shaped bodies, 260 to 300 μ long and up to 14 μ wide. These bodies he designated as gemmae, though explaining that unlike the gemmae in species of *Saprolegnia* they did not represent functionally frustrated oogonia, or frustrated sporangia, or mycelial segments delimited by cross-walls. His description of their development offers obvious correspondence more especially to conidial development in the zoopagaceous form I have described as *Stylopage rhabdospora* (13), though their reported disarticulation previous to any septation or evacuation of the slender frangible sterigmatic attachment would seem alien to all modes of conidial disjunction so far observed in known members of the Zoopagaceae. In *Z. tentaculum*, judging from Karling's (26) original description of this somewhat smaller congeneric rotifer-capturing species, elongated fusiform gemmae or conidia, unquestionably homologous to those of *Z. insidians*, are not only produced but also become disjointed after a manner familiar among the Zoopagaceae: the production of these spindle-shaped bodies, like the production, again, of conidia in *S. rhabdospora*, taking place successively at the tips of fertile hyphae given to repeated subapical prolongation; their disjunction thereupon being accomplished, much like conidial disarticulation in my *Cochlonema nematospora* (13) and my *C. megaspirema* (14), after evacuation of protoplasm from the narrow sterigmatic attachment has been followed by deposition of retaining walls at the ends of the separated protoplasts. The presence of a number of septa within the several gemmae of *Z. insidians* that were figured by Arnaudow in advanced stages of germination, makes for

further correspondence with the conidia of *S. rhabdospora*, since the latter, too, lay down retaining walls as their contents migrate progressively into elongating germ hyphae. Though containing a manifestly large mass of protoplasm newly elaborated during periods when abundant nourishment sustained high vegetative vigor, the gemmae of *Z. insidians* always gave rise to predaceous mycelia, never being found undergoing conversion into zoosporangia. This was true also of the conidia of *Z. tentaculum* whose content of protoplasm should be sufficient for fairly liberal zoospore production even if their more modest measurements—40 to 80 μ in length and 3 to 6.5 μ in width—brings them well within the range of dimensions displayed by the conidia of known members of the Zoopagaceae. Indeed, zoosporangia were not seen in *Z. tentaculum* at all, nor, for that matter, antheridia and oogonia.

The sexual stage found by Arnaudow in *Zoophagus insidians*—its connection with the rotifer-capturing vegetative stage would seem amply attested by the predaceous spurs shown arising from the undulating sexual branches as well as from the main hyphae bearing these branches (3: fig. 5)—was considered by him to indicate relationship of the fungus in the Pythiaceae rather than in the Saprolegniaceae. However, his illustrations of the sexual stage seem rather more strongly suggestive of the Zoopagaceae than of any other family of Phycomycetes. Certainly in the Zoopagaceae it is more usual than in the Pythiaceae for the sexual branches to make contact with each other before they have become differentiated distally into conjugating organs; and much more usual, also, for these branches to fuse apically and to lay down a special cross-wall soon after they have been brought together—at a time, that is, when the materials required for the formation of a zygospore have only in small part been accumulated locally. While in some species of *Pythium*, as notably in *P. vexans* deBary, the sexual branches likewise are brought together very early, so that the oogonium and the antheridium develop in intimate contact with each other, these organs are not ordinarily delimited by cross-walls until on reaching their definitive size they contain all the protoplasmic materials destined to enter into the formation of the oospore. Again, while

in many species of *Pythium*, as, for example, in *P. ultimum*, an intercalary antheridium consisting of a segment of the oogonial hypha adjacent to the oogonium may not be distinguished outwardly from other filamentous parts, an antheridium borne terminally on a branch is nearly always distinguishable from neighboring hyphal parts by its greater width or, perhaps, by its clavate or crook-necked shape. Now, as the sexual apparatus ascribed to *Z. insidians* is of strictly diclinous origin, all antheridia present should be of the more easily recognizable type. Yet none of the hyphal parts attached to the 3 globose bodies drawn by Arnaudow as representing nearly mature oogonia (3: fig. 5, L, M, N) show any modification marking them as antheridia of a pythiaceous fungus. For this reason, mostly, the 3 units of sexual apparatus show less resemblance to diclinous sexual apparatus of any species of *Pythium* with which I am acquainted than to the diclinous sexual apparatus of those species in the Zoopagaceae—*Zoopage phanera* Drechsl. (9) and *Z. atractospora* Drechsl. (13) may be cited as examples—wherein the zygothoracic branches become neither much swollen nor spirally involved, and wherein the zygosporangium develops in an intercalary position not far from the juncture of the gametangial elements.

From resemblances both in its sexual and its asexual development Arnaudow's gemma-producing fungus would seem to belong more probably in the Zoopagaceae than in the Pythiaceae or Saprolegniaceae. Among known members of the Zoopagaceae its production of gemmae successively on repeatedly elongated submerged hyphae finds ecological parallelism in the normally submerged conidial development of my *Stylopage scoliospora* (17); the asexual reproductive bodies of the two species alike expressing in their unbranched unappendaged condition adaptation to a submerged mode of life, and alike offering contrast with the conidia of *Acaulopage dichotoma*, which through their branched and appendaged condition more nearly betray adaptation to a floating aquatic existence. It must be admitted, of course, that all correspondence between the gemma-producing fungus and the Zoopagaceae would need to be regarded as illustrative of convergence, and as being wholly without taxonomic import, should

the production of gemmae described by Arnaudow prove to be unmistakably associated with zoosporangial development in one and the same fungus. The evidence hitherto given in favor of such association appears far from decisive; for Arnaudow, as has been noted, explicitly admitted some uncertainty in regard to the connection between his *Pythium*-like zoosporangia and his *Zoophagus insidians*, while Valkanow in claiming to have observed an unambiguous connection between evacuation tube and mycelium did not state that the mycelium in question also gave rise to gemmae. There is reason to suspect, certainly, that the binomial which Sommerstorff established on a purely vegetative stage has been applied by different investigators to fungi widely different in manner of reproduction and in taxonomic relationships. No diversity of application, however, can account for the curious fact that of the several investigators who from first-hand observations ventured to assign the species to the Oomycetes, the one who assigned it most unreservedly to the Pythiaceae ascribed to it a type of reproduction wholly alien to that family, whereas the one who claimed to have found its rotifer-capturing mycelium most unmistakably connected with apparatus serving in zoospore development of a type frequent in *Pythium* insisted emphatically that the species cannot correctly be referred to the Pythiaceae.

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EXPLANATION OF FIGURES

FIG. 1. *Cystopage intercalaris*; drawn to a uniform magnification with the aid of a camera lucida; $\times 500$ throughout. *A*, Portion of mycelial hypha with a captured specimen of *Plectus parvus*; invasion of the animal has been started by the intrusion of four haustorial branches. *B*, Portion of hypha with a captured specimen of *P. parvus* in a somewhat later stage of invasion. *C, D, E*, Portions of mycelial hyphae, each with a captured specimen of *P. parvus* that is invaded from head to tail by assimilative filaments. *F; G; H, a, b; I-Z*: Chlamydospores with adjacent portions of the hyphae bearing them; showing variations in size, in shape, and in manner of attachment of the reproductive bodies; and illustrating the distribution of septa in the empty hyphae, as well as the distribution of the perforated lumps of adhesive material that earlier had served in capture of nematodes.

FIG. 2. Sexual stage of a nematode-capturing fungus belonging in the Zoopagaceae; drawn to a uniform magnification with the aid of a camera lucida; $\times 1000$ throughout. *A*, Two intersecting mycelial hyphae, *a* and *b*, to each of which is attached an empty integument of a nematode referable apparently to *Acroboloides bütschlii*; the two hyphae have put forth a pair of sexual branches which after fusing apically have produced a zygosporangium on a stalk arising from a position close to their junction. *B*, Two intersecting mycelial hyphae *a* and *b*, from which have been extended two pairs of sexual branches that after fusing have given rise to the two zygosporangia *c* and *d*. *C*, Two intersecting mycelial hyphae, *a* and *b*, from which have been extended a pair of interinvolved sexual branches; these branches, after fusing apically, have given rise laterally to a zygosporangium about 15μ below their junction. *D*, A mature or nearly mature zygosporangium surrounded by an irregularly thickened zygosporangial envelope. (For the sake of clearness the sexual branches are further shown, in whole or in part, without stippling, in supplementary drawings enclosed by broken lines; the small letters by which they are designated in these drawings correspond to the letters designating the parent hyphae.)

FIG. 3. Drawn to a uniform magnification with the aid of a camera lucida; $\times 1000$ throughout.

A-M, Cochlonema pumilum: *A*, Small specimen of host animal, *Euglypha levis*, within which is contained a small thallus of the parasite that has devoted all its contents to the production of conidial apparatus; a few conidia are shown, some attached, others detached. *B*, A small specimen of *E. levis* within which a mature zygosporangium is shown attached to the membranous envelope of the small thallus that gave rise to it. *C*, A large specimen of *E. levis* within which is contained, besides three ungerminated supernumerary conidia, a well developed thallus of the parasite. *D*, A large specimen of *E. levis*, containing a thallus whose entire contents have migrated into the globose zygosporangium. *E, F, G*, Specimens of *E. levis*, each containing a thallus from which protoplasmic materials are still migrating into an enlarging zygosporangium. *H, I, J*, Large specimens of *E. levis*, each containing a nearly mature zygosporangium and the empty envelope of the thallus from which it originated. *K*, A large specimen of *E. levis* within which a zygosporangium is being formed apparently in a position between the proximal end of the thallus and the empty membrane of the parent conidium. *L, M*, Large

specimens of *E. levis*, each containing a fully mature zygospore and the empty envelope of the thallus from which the zygospore originated.

N-P, Cochlonema ozotum: *N, O*, Two empty testae of *Sphenoderia dentata*, each containing the empty membranous envelope of a thallus whose protoplasmic contents went into the production of conidial apparatus. *P*, Detached conidia, showing usual variation in size and in shape.

Q-U, Stylopaga minutula: *Q*, A mycelial hypha from which a dichotomously branched haustorium has grown into a captured amoeba, *a*; the hypha has further given rise to a conidiophore, *b*, bearing a conidium, *c*. *R*, Portion of mycelial hypha which has given rise to a young conidiophore, *a*, and to a somewhat older conidiophore, *b*, whereon two conidia, *c* and *d*, have been produced successively. *S*, Detached conidia, showing usual variation in size and in shape. *T, U*, Germinating conidia.

FIG. 4. *Acaulopage dichotoma*; drawn to a uniform magnification with the aid of a camera lucida; $\times 1000$ throughout. *A*, Portion of mycelium to which are attached six captured amoebae, *a-g*. *B-E*, Portions of hyphae, to each of which is attached a captured amoeba. *F, G*, Portions of mycelium, each bearing a conidium in an early stage of development. *H-S*, Detached conidia, showing usual variations in respect to size and manner of branching, as well as in respect to number and length of the empty membranous appendages.

NOTES ON THE GEOGLOSSACEAE OF BERMUDA

J. M. WATERSTON, J. W. ŠINDEN AND H. H. WHETZEL

(WITH 1 FIGURE)

The Geoglossaceae are well represented in Bermuda by some four genera and seven or eight species. The following notes are based on collections made over a period of seventy years. The earliest collection was that by H. N. Moseley, Naturalist of the British Challenger Expedition, in 1873. Berkeley (1, 2) published two lists of Bermuda fungi based on Moseley's collections which were later revised by M. C. Cooke and published by Hemsley (5). Only one species, *Trichoglossum hirsutum* (Pers.) Boud. (recorded as *Geoglossum hirsutum* Pers.), was reported.

Extensive collections of fungi were made both by Dr. B. O. Dodge in 1911 and by Dr. F. J. Seaver in 1912. A list of these, together with some additional species collected by Dr. Stewardson Brown and Dr. N. L. Britton, was published by Seaver (6, 7). These collections added *Geoglossum nigrum* Cooke and *Trichoglossum hirsutum* f. *Wrightii* Durand to the list. The latter was raised to specific rank by Durand (4) after an examination of Bermuda material and named *Trichoglossum Wrightii* Durand. A further record, *Geoglossum pumilum* Winter, was added by Durand (4) and was later noted by Seaver (8).

Further collections were made by H. H. Whetzel during the years 1921 and 1922, whilst acting as the first plant pathologist appointed to the Bermuda Department of Agriculture. Additional collecting was done by Lawrence Ogilvie, appointed plant pathologist in 1923, in coöperation with the junior author and with Dr. F. J. Seaver who revisited the Colony in 1926.

Dr. Seaver revisited Bermuda on two further occasions during the autumns of 1938 and 1940 and, in company with the senior author, made further collections of fungi.

Over thirty separate collections of Geoglossaceae are listed from Bermuda in the Herbarium of the Department of Plant

Pathology at Cornell University. Most of the specimens have been collected during the winter months (November to February) when climatic conditions appear to be most favorable. The weather experienced during this period is usually cool (55°–65° F.) and the monthly rainfall is a little over four inches. The mean relative humidity during this period ranges from 76–78% and the number of hours of sunshine per day ranges from 5.5 to 6.6 in comparison with from 6.4 to 9.6 of the summer months.

Bermuda's soil is derived from aeolian limestone of recent geological age and as a result is uniformly calcareous with a pH ranging from 7.5 to 7.8. The topography is hilly with local broad valleys occupied by fresh water or brackish marshes. Damp pockets of soil in these rocky hillsides, as well as on lower ground, form ideal habitats for species of Geoglossaceae.

Recorded below are two species of *Trichoglossum*, three or possibly four species of *Geoglossum*, one species of *Gloeoglossum* and a species of *Mitrula* new to science. New Bermuda records are designated with an asterisk. One of us (J. W. S.) is responsible for making most of the determinations. Unless otherwise stated, the numbers attached to the collections refer to the accession number in the Herbarium of the Department of Plant Pathology, Cornell University.

TRICHOGLOSSUM HIRSUTUM (Pers.) Boud.

This species was first collected by Moseley in 1873 on dead *Sphagnum* under ferns in Devonshire Marsh. The record was reported by Berkeley (1, 2) as *Geoglossum hirsutum* Pers. and also by Hemsley (5). Seaver (6) searched the same station diligently in 1916 and states he was unable to duplicate the collection. Four collections were subsequently made: Whetzel, Nov. 1921–Feb. 1922, 33200, 33209; Whetzel, Seaver and Ogilvie, Jan. 1926, 33192, 33193.

Habitat: On soil in Paget Marsh in association with *Geoglossum fallax* Durand and in Walsingham.

TRICHOGLOSSUM WRIGHTII Durand.

This was first listed by Durand (3) as a form of *Trichoglossum hirsutum* based on two specimens from Cuba. It was later raised

to specific rank by Durand (4) after examination of Bermuda material collected Nov. 29–Dec. 14, 1912 (Britton, Brown and Seaver, 1404). Bermuda material was also examined by Sinden and Fitzpatrick (10) in a critical review of the genus.

This species is one of the commonest collected in Bermuda. Whetzel, Jan. 20, 1922, 33201; Whetzel, Seaver and Ogilvie, Jan. 1926, 33183, 33185, 33189, 33190, 33194; Seaver and Waterston (9), Nov. 28–Dec. 14, 1938 (N. Y. B. G. 178).

Habitat: Among crab grass, *Stenotaphrum secundatum* (Walt.) Kuntze, "Fruitlands" and "Argyll" in Warwick, Agricultural Station, Walsingham, "Harrington House."

GEOGLOSSUM NIGRITUM Cooke.

This species was first reported by Seaver (6) who found it abundant on rocky hillsides among mosses (Nov. 29–Dec. 14, 1912). It is another very common species and is represented by ten separate collections in the Cornell University Herbarium: Whetzel, Dec. 1921, 33207; Whetzel, Feb. 1922, 33208; Whetzel, Seaver and Ogilvie, Jan.–Feb. 1926, 33184, 33186, 33187, 33188, 33191, 33195, 33197, 33198.

Habitat: Rocky hillsides among mosses.

**GEOGLOSSUM FALLAX* Durand.

This species is represented by two collections: Whetzel, Jan. 1922, 33204; Whetzel, Seaver and Ogilvie, Jan. 1926, 33203.

Habitat: Found in association with *Trichoglossum hirsutum* (Pers.) Boud. on soil in Paget Marsh.

**GEOGLOSSUM PYGMAEUM* Gerard.

There are three collections of this species: Whetzel, Jan. 1922, 33205, 33210; Whetzel, Seaver and Ogilvie, Jan. 1926, 33206.

Habitat: Found in association with *Geoglossum nigrum* Cooke in Walsingham.

GEOGLOSSUM PUMILUM Winter.

A single collection by Ogilvie was taken on Jan. 26, 1926, 33218, in Walsingham. There is one other record of this species in Bermuda collected by Britton, Brown and Seaver, Nov. 29–Dec. 14, 1912 (N. Y. B. G. 1364). Durand (4) records the posi-

tion of this species as "closely allied to *G. pygmaeum* Ger." He adds, "I have not seen Winter's type, so that the identification depends upon the description only."

Habitat: Damp soil in woods.

**GLOEOGLOSSUM GLUTINOSUM* (Pers.) Durand.

There are three collections of this interesting species: Whetzel, Jan. 1922, 33199, 33202; Whetzel, Seaver and Ogilvie, Jan. 1926, 33196.

Habitat: Soil among grasses in Walsingham.

**Mitrula bermudiana* Waterston, sp. nov. (FIG. 1)

Plants small, solitary, slender, 1 cm. high; ascigerous portion distinct from stem below, 5 mm. long, 2 mm. broad, 0.5 mm. thick, hygrophanous tan in color; stem equal.

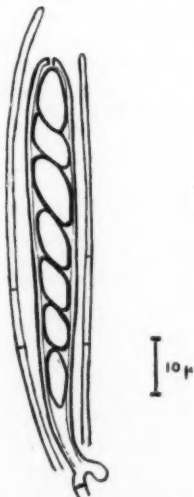


FIG. 1. *Mitrula bermudiana*, ascus and paraphyses.

Asci clavate, apex narrowed, the pore blue with iodine, $81-105 \times 6-9 \mu$, mean $90 \times 6 \mu$; spores 8, obliquely uniseriate, hyaline, guttulate, continuous, smooth, ellipsoid, $9-15 \times 3-4 \mu$, mean $12 \times 3 \mu$; paraphyses hyaline, filiform, 2μ thick, simple, with few septa.

Ascomatibus minutis, solitariis, 1 cm. alt.; clavis a stipite distinctis 5 mm. long., 2 mm. diam., pallide brunneis; ascis clavatis apice attenuatis, jodo caerulescentibus; $81-105 \times 6-9 \mu$ 8-sporis; sporis monostichis, hyalinis, ellipsoideis, levibus, $9-15 \times 3-4 \mu$; paraphysisibus hyalinis, filiformibus, saepe septatis, 2μ diam.

Habitat: Type collected in soil among rocks on hill top, Walsingham, Jan. 20, 1926, by H. H. Whetzel, 33212. An earlier collection by Whetzel from a grassy hillside at Walsingham, on Jan. 20, 1922, 33211, proved immature. Type deposited in Plant Pathology Herbarium, Cornell University, Ithaca, N. Y., as No. 33212.

The non-septate, ellipsoid, uniseriate spores distinguish this species from all those previously described by Durand (3) from North America which are characterized by the presence of paraphyses in the ascoma. No records of this genus have hitherto been recorded from Bermuda.

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THE FUNGUS CAUSING ZONATE LEAFSPOT OF COWPEA

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(WITH 2 FIGURES)

A disease of cowpea (*Vigna sinensis* (L.) Endl.), which has been designated here as the zonate leafspot (FIG. 1, A-B), was much in evidence, particularly in the Southern States during the 1943 growing season. The disease has been known for many years as a minor trouble of cowpea and the causal organism has been called *Amerosporium oeconomicum* Ellis & Tracy. One finds, however, that the fungus causing this leafspot has septate conidia, hence it does not agree with the description given by Ellis and Tracy (9, p. 102), and should not be referred to the genus *Amerosporium*. Because this leafspot of cowpea is so striking, many collectors have referred their specimens to *Amerosporium*, however, probably without a microscopic examination of the causal fungus. Since the leafspot is common, apparently wherever cowpeas are grown, and since so many have either wrongly identified the causal fungus or left their specimens undetermined, as indicated by the number being sent in for identification, both the disease and the causal organism appear to warrant further study.

HISTORY AND DISTRIBUTION

Ellis and Tracy (9) in 1888 described *Amerosporium oeconomicum* as a new species, producing orbicular spots, 2-6 mm. in diameter, on leaves of "cowpea," at Starkville, Mississippi. Ellis and Everhart issued the same fungus on "*Dolichos arvensis*" as

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No. 2574 (1891-92) in their exsiccati *North American Fungi*, under the name *Amerosporium Dolichi* Ellis & Ev., but without a description, hence a nomen nudum. Farlow (11, p. 211) points this out by saying "The name *Amerosporium oeconomicum* and *A. Dolichi* are founded on material of the same host, locality, and collector, and J. B. Ellis states in a letter that they are synonyms."

Later Tracy and Earle (24, p. 112) repeated the original description, giving the host as *Dolichos sinensis* and adding Biloxi, Miss., as an additional locality. Atkinson (3, p. 33) cited collections by himself and Duggar at Auburn, Ala. Underwood and Earle (25, p. 175) and Earle in Mohr's *Plant Life of Alabama* (12, p. 261) repeated Atkinson's citation, changing the host designation to *Vigna catjang*. North Carolina was added to the area of occurrence by Stevens and Hall (21), who compared the symptoms produced by *Amerosporium* with those caused by *Cercospora Dolichi*, noting that the former at times caused defoliation.

The fungus has been noted in Connecticut by Clinton (6), in Indiana by Osner (13), and attracted some attention during a number of years in Delaware (1, 2). Only one report of the occurrence of the fungus outside of the United States has been found. Faris (10) found it in the Dominican Republic in 1923 and the record was later included by Ciferri (4) in his comprehensive account of the fungi of that country. The files of the Plant Disease Survey indicate its presence also in Arkansas, Florida, Georgia, South Carolina, and Virginia.

Spegazzini's genus *Amerosporium* was described (19, p. 20) with non-septate conidia and the several species assigned to it by other mycologists have conformed, except in the case of *A. oeconomicum*. Petrak and Sydow (16, 17) investigated the type species and certain other members of the genus at some length and decided that it could properly be retained with certain emendations. They made no mention of Ellis and Tracy's species.

FIG. 1. *Aristastoma oeconomicum* on cowpea; A, infected leaf showing 3 lesions, bearing pycnidia and alternating zones of brown and white tissue. At right, lesion has dropped out resulting in a "shot hole" effect. Solid brown lesion at left center caused by *Cercospora Dolichi* Ellis & Ev., $\times 1$; B, single lesion with irregularly arranged pycnidia, $\times 8$.

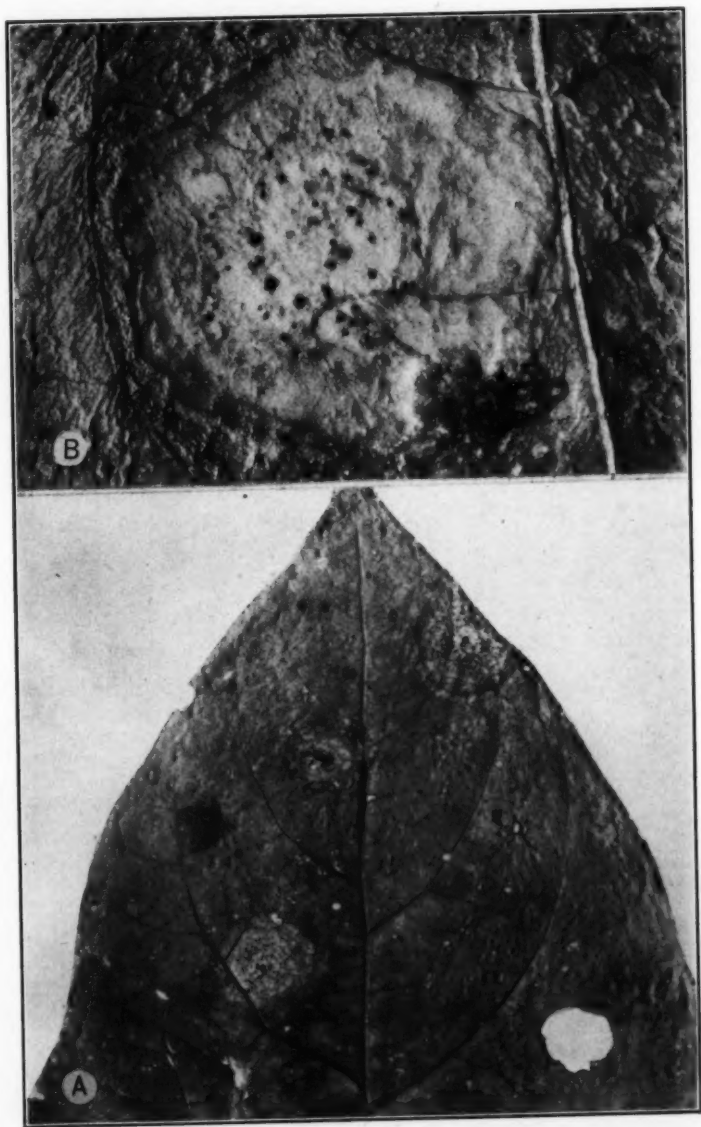


FIG. 1.

It is evident, of course, that Ellis and Tracy, in placing their species in *Amerosporium*, overlooked the fact that the conidia are septate—if not at first, certainly at maturity. These authors merely recorded them as “nucleate.” Clinton (6) appears to have been the first to observe the septate condition, commenting that:

“This exsiccati specimen (Ellis and Everhart, No. Amer. Fungi, No. 2574) plainly shows that the spores are septate (about three septate when old), and the specimens collected in Connecticut also indicate that they would become septate with age. This may mean that the fungus belongs in a different genus, since the spores of *Amerosporium* are said to be continuous.”

Tehon (23, p. 445) also noted the septate condition of the conidia, since in discussing his newly described species, *Chaetoseptoria Vignae*, he says, “In its external aspect this fungus is similar to that of Tracy and Earle's incorrectly placed *Amerosporium oeconomicum*, which attacks the same host.”

Present studies have definitely confirmed the presence of septate conidia which makes it necessary to reassign the fungus generically. A search of the literature suggests the possibility of placing this cowpea fungus in one of four genera, *Chaetosticta*, *Trotteria*, *Dasypyrena*, or *Aristastoma*.

The genus *Chaetosticta* was established by Petrak and Sydow (15) to care for *Chaetomella perforata* Ellis & Ev. (8) which they pointed out could not properly be included in *Chaetomella*. Ellis (7), however, later found this fungus to be an ascomycete and renamed it *Venturia occidentalis* Ellis & Ev., which Saccardo transferred to *Acanthostigma occidentale* (Ellis & Ev.) Sacc. The genus *Chaetosticta* was described as having superficial pycnidia, sparingly clothed with straight, black, continuous bristle-like hairs, more thickly set around the ostiole. These characteristics, contrasted with the imbedded pycnidia and the single ring of setae around the ostiole as noted hereafter for the cowpea fungus, to say nothing of the fact that apparently an ascomycete is involved, appear sufficient to eliminate *Chaetosticta* from further consideration.

Trotteria was described by Saccardo (18) as having superficial, hypophyllous fruiting bodies clothed with septate, brown setae. Portions of the type collections of Saccardo's two species were examined and confirmed his general characterization, which effectively removes *Trotteria* from the discussion as a possible generic designation for a fungus with imbedded pycnidia.

Clements and Shear (5) consider *Chaetosticta* and *Trotteria* synonymous with *Dasyphyrena*, which was originally described by Spegazzini (20) and accepted by v. Hoehnel (26). Petrak (14) and Petrak and Sydow (15), however, have pointed out that Spegazzini's fungus is a Pyrenomycete, which in turn disposes of *Dasyphyrena*.

Tehon (22) described the genus *Aristastoma*, typified by *A. concentrica* on *Vigna sinensis*, in 1933 and his description fits in all particulars the cowpea fungus, which we are considering. He notes particularly imbedded pycnidia with a comparatively wide mouth, surrounded by a ring of septate setae and 1-4-septate conidia. However, the erecting of a new genus and species by Tehon did not help clear up the tangled nomenclature because he did not consider Ellis and Tracy's *Amerosporium oeconomium*, described in 1888 as the cause of the leafspot of cowpea in question.

SYMPTOMS OF THE DISEASE

The symptoms of the leafspot on cowpea are essentially as described by Ellis and Tracy (9) and by Tehon (22). There appears to be greater variation, however, in the size of the spots than was mentioned by them, because we find lesions measuring up to 16 mm. in diameter (FIG. 1, A). Spots are usually more or less circular, but they may coalesce and become quite irregular. Also, we find that as the fungus develops in a lesion the tissue becomes papery and brittle, resulting in the dropping out of the whole lesion, producing a "shot hole" effect (FIG. 1, A). The pycnidia are mostly produced in this white, papery center of the lesions (FIG. 1, B), but they are sometimes found extending beyond this region in the brownish-red tissue forming the outer portion of the spots.

MORPHOLOGY AND NOMENCLATURE OF THE FUNGUS

Pycnidia are usually spherical (FIG. 2, A), erumpent, epiphyllous; the 10 measured ranging from 155–260 μ , averaging 208 μ ; ostiole circular, 15–30 μ , averaging 23 μ , surrounded by a ring of more or less upright setae, these blackish-brown at the base, becoming lighter toward the tip, 0–6 septate, straight, 30–170 μ long by 6–15 μ wide. The setae are usually broken in packets if the specimens have been handled roughly and may, therefore, appear rather blunt upon examination. Conidia are rather pointed, oblong, 1–7, mostly 3-septate, but in immature pycnidia many conidia are non-septate; 16–42 by 4–6 μ , averaging 26.0 by 4.7 μ . Conidia from different pycnidia may differ quite widely (FIG. 2, C–D) even though mounts are made from the same leaf. The fungus was found to grow readily in pure culture and single-conidium isolations have been used in the present study.

The above measurements of the various fruiting structures are those for the specimens that were examined by the writers, while the measurements in the description of the new combination that follows differ slightly, since they are the over-all measurements, including those of other investigators.

Since the fungus under discussion has septate conidia, it is obvious it does not belong in the genus *Amerosporium* which is characterized by species having non-septate conidia. It seems apparent, however, that the cowpea fungus can be properly referred to the genus *Aristastoma*, but that a new combination becomes necessary, inasmuch as the specific epithet of Ellis and Tracy has priority.

Aristastoma oeconomicum (Ellis & Tracy) Tehon,² comb. nov.

Syn. *Amerosporium oeconomicum* Ellis & Tracy in Ellis & Ev.
Jour. Myc. 4: 102. 1888.

² We credit the combination to Dr. L. R. Tehon with his permission on the basis of his use of the binomial on one of the herbarium specimens of the fungus that he kindly loaned us for study.

FIG. 2. *Aristastoma oeconomicum*. A, pycnidium with ostiole surrounded by setae, $\times 280$; B, setae, showing septa, and tapering to fairly acuminate tips, $\times 600$; C, conidia with a larger proportion than usual showing more than 3 septa, $\times 600$; D, conidia showing many with fewer than 3 septa, probably from an immature pycnidium, $\times 600$.

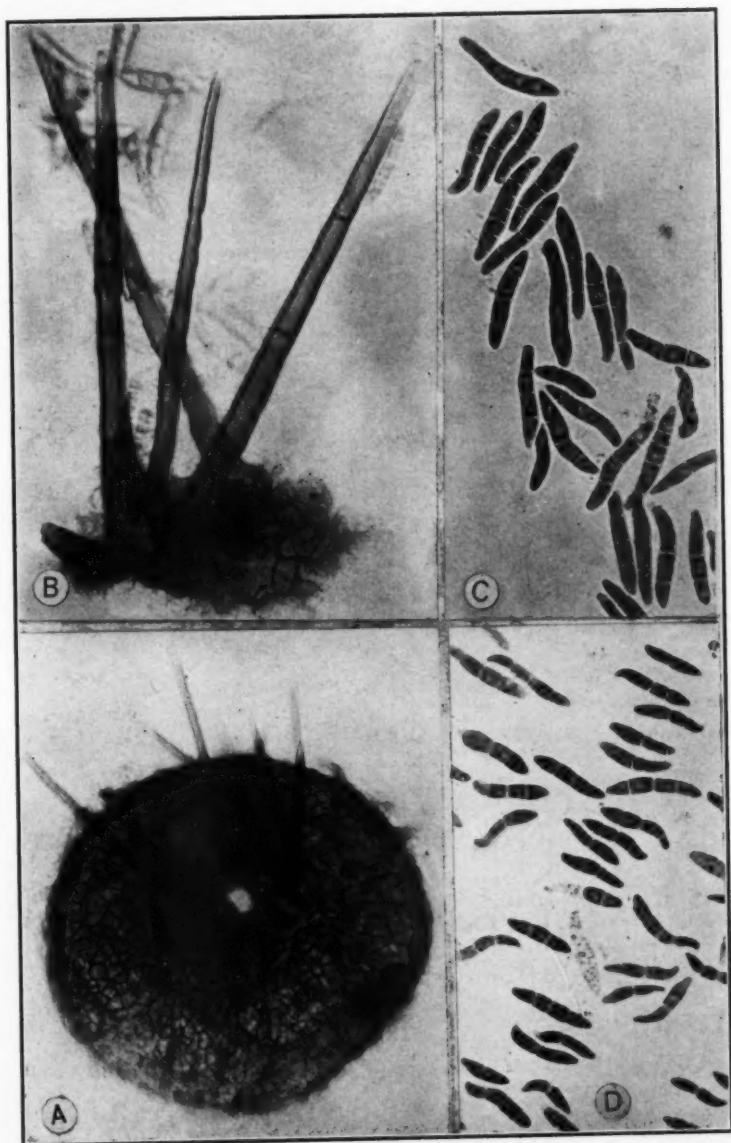


FIG. 2.

Aristastoma concentrica Tehon, Mycologia 25: 248-249. 1933.

Folicle, causing circular to irregular spots 2-16 mm. in diameter, these marked more conspicuously above than below by alternating concentric zones of brownish-red and white tissue, the margin brownish-red, sometimes affected tissue dropping out causing a "shot hole" effect; pycnidia spherical to applanate, arranged irregularly, usually in white zone of spots only, but sometimes extending into brownish tissue, erumpent, epiphyllously only, membranaceous except near the ostiole, 155-270 μ in diameter, ostiole circular, 15-35 μ in diameter, crowned by a ring of more or less upright setae, these blackish-brown at base, becoming lighter toward the apex, 0-6-septate, pointed, straight, 20-170 μ long by 6-15 μ wide; conidia oblong, 0-7, mostly 3-septate, 15-42 \times 4-6 μ .

On leaves of *Vigna sinensis* (L.) Endl., Illinois (Tehon No. 5453 type), Alabama, Arkansas, Delaware, Florida, Georgia, Indiana, Mississippi, North Carolina, South Carolina, Virginia; *Phaseolus* sp., Biloxi, Miss.; *Phaseolus angularis*, Arlington, Va.; *Phaseolus Max*, Arlington, Va.; *Phaseolus radiatus*, Arlington, Va.; *Phaseolus vulgaris*, Brunswick, Ga. As noted previously, reports of the species on *Dolichos* spp. and *Vigna catjang* are properly *Vigna sinensis*, cowpea.

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NOTES ON THE PILEATE HYDNUMS

WALTER H. SNELL

Precisely why one who can think of enough problems in the *Boleti* to last him for at least 25 years should ask for more trouble by becoming interested in the hydnums, may be somewhat difficult to explain. None but a few species of *Boleti* are at all abundant and one can collect for years to find that he has seen single specimens of most species only a very few times. The hydnums occur even less commonly. Banker (1, pp. 99-100) after years of study of this group spoke in a disappointed manner of the "lack . . . of getting suitable material," "the local character of the distribution of these plants," "the comparative rarity with which they are found," the intermittence of their appearance.

The fact is, however, that as is the case with the *Boleti*, the pileate hydnums have long fascinated me for some unexplainable reason and similarly the difficulties involved in the identification and identity of specimens provide a stimulating challenge. Also, the hydnums are to be found in the same habitats as the *Boleti* and their collection therefore involves no extra or different effort in the hunting. Furthermore, whereas the study of the *Boleti* has become a rather intense preoccupation for a good part of the time available, if not actually at times a sort of mycological Old Man of the Sea, the hydnums have been a diversion and have provided mental refreshment.

Therefore, it is hoped that at odd times some contribution can be made to our knowledge of this rather generally neglected group of fungi.

CALODON GEOGENIUS (Fries) Quél.

Until very recently, this species was all but unknown on this continent, at least as far as I am aware of publications on the subject. In 1886, Peck (10, p. 43) had reported it from South

Balston, New York, and Banker, who had included it in a list of "Species Dubiae et Inquirendae" (1, p. 135), later verified it in 1913 (3, p. 204). In 1940, Wehmeyer (12, p. 100) reported it in Nova Scotia and in 1942, Coker (9, p. 94) reported it from Georgia near the South Carolina line. Finally, it was reported as collected by Henry A. C. Jackson and myself in County L'Islet, Quebec, following the 1941 Foray (11, p. 666—incidentally, with the specific name not in generic agreement).

As far as the records go, therefore, this species is very rare and very "spotty" in occurrence. Like several other species of the pileate Hydnaceae, it is at present known only from the northern and southern ends of the Appalachian system. This is probably only because of the fortuitousness of the collecting of these fungi, although it must be remarked that the eastern part of the United States has certainly been more carefully searched than contiguous portions of Canada.

The records make no mention of the abundance of this species in the few cases reported and one is left with the impression that it does not fruit often or in a prolific manner. In the proper places, however, it can be not uncommon or sparse. Jackson has found it in three patches of woods near St. Aubert, County L'Islet, Quebec. In one patch of woods which provides especially good hydnum collecting, he has collected it every year for the past six years and it has been abundant to very abundant when it was at all moist.

The records of the habitat of this species are not precise as to desired details. Peck merely said "woods" and Coker mentions only the deep humus on the bank of a creek. Wehmeyer is somewhat more specific, for he says "Under conifers." At the St. Aubert locations in the province of Quebec where Jackson and I found it, it has occurred under coast white cedar or cedar and spruces. We did not make any effort to determine with which of these trees the mycelium was connected.

Coker's description and photographs indicate that in the southern extremity of the range, pilei are more likely to be single, simple, plainly stipitate and gregarious, although he says that they are often confluent and complicated. Wehmeyer, on the

other hand, emphasizes the squat, complicated and almost sessile characters of the fructifications with fused stems. It is thus that Jackson and I have found it, and even more pronouncedly so. The fructifications often have no determinable stipes but are fused, concrescent, almost amorphous masses, sometimes as if they grew out of an irregular, straggling fissure in the soil, and they are long-obconic in section the short way and scarcely flaring. In fact, I have rarely seen single stipitate specimens with a regular pileus.

Coker and Wehmeyer emphasize the darker colors which this species shows—pale to deep wood-brown to dark olive-brown to olive-black, with olive-yellow tints, of course with very light to bright sulphur-yellow margin. Possibly I may have found much younger or fresher specimens but the colors have been much lighter—sulphur-yellow to fuscous or grayish-ochraceous, with tinges of yellowish or deep olive-buff.

I find the spores wood-brown to army-brown in deposit, pale yellowish under the microscope and $3.5-5 \times 3-4 \mu$, or essentially as given by Coker and Wehmeyer, except that Wehmeyer's measurements are slightly smaller.

CALODON FERRUGIPES AND HYDNUM BREVIPES

These two species are additional examples of the distributional situation mentioned in connection with *Calodon geogenius*—being known, in the literature at least, only from widely separated points and at extremes of a known range. These species were both described by Coker from North Carolina. *C. ferrugipes* was described as a *Hydnellum* in 1919 and was not reported again until 1938 from Manitoba by Bisby *et al.* (5, p. 80). It has been found in Florida by Murrill. In 1940, I collected it at Friendship, Maine.

Hydnum brevipes was described as a *Sarcodon* in 1939. In 1940, Jackson and I collected it near Elgin Road, County L'Islet, Quebec, and in 1941 I found it at Friendship, Maine. All three of these collections were identified by Dr. Coker.

In the generic arrangement preferred by me, these species should be **Calodon ferrugipes** (Coker) Snell, comb. nov. and **Hydnum brevipes** (Coker) Snell, comb. nov.

HYDNUM ROSEOLUM AND H. AMARESCENS

Banker in 1913 (2, p. 16) described the former species from specimens collected by Murrill and House in North Carolina as a small, pale rose-colored *Sarcodon*, without making mention of odor or taste. In 1926, Coker (7, pp. 274-275) included Banker's species in *H. amarescens* Quélet, but in 1939 (8, p. 375), with "good fresh specimens" at hand, he decided that "the two species can easily be separated by the mild taste, very thin flesh, much shorter spines and paler, more rosy color." He redescribed the species, still in the genus *Sarcodon*.

In 1942, Donald P. Rogers collected a roseate hydnum in Rhode Island, and whichever species it may prove to be, it is an interesting collection. If it should be *amarescens*, it would be the first time that it has been found on this continent, to my knowledge, except as confused with *roseolum*. If it is *roseolum*, here is another example of a rare species known only from two localities widely separated, north and south.

The possible identity and value of this specimen were not recognized at the time of collection and therefore its taste and some other features in the fresh condition were not noted although partial notes were made. Consequently, attempts made to identify it in the dried state are considerably handicapped. I am, however, unable to detect any bitterness of taste of the flesh and it would seem that this should not be difficult if the specimen is *amarescens*, since this species is supposed to be so acrid as to constrict the throat when tasted. Other bitter fungi, such as *H. fennicum* and *Boletus felleus*, are bitter enough to the taste when dry. Furthermore, the deep rosiness, especially of the flesh, and other characters appear to make the specimen fit the description of *roseolum* better than that of *amarescens* and therefore, I am calling it the former.

Banker and Coker give the width of the pileus as 3 or 4 cm. This specimen is 7 cm. broad. The pileus is also more glabrous, subtomentose only in spots and with only a slight tendency to be tomentose-squamulose. Also, the spines are up to 2 mm. long, although most of them are only 1 or 1.5 mm. long, somewhat longer than given by Banker and Coker, but still shorter than those of *amarescens*. Further, the spores in mass as found

in depressions on the stipe are definitely fawn-color instead of pale brown as given in other descriptions. Otherwise, the specimen seems to be in accord with the descriptions of *roseolum*, especially as to the stipe tapering downward to a greenish-blackish base and a somewhat radicating tip.

In the genus *Hydnum*, this species should be *H. roseolum* (Banker) Snell, comb. nov.

RHODE ISLAND SPECIES OF PILEATE HYDNUMS

Mycologically, Rhode Island has been more or less of a *terra incognita* at least as far as published data are concerned—from this point of view probably the poorest known political entity north of the Rio Grande, if not on the entire continent. The green plants of the State have been well known from the earliest times as a result of the studies of several well known botanists, but Bennett's publication of 1888 (4, pp. 76–94) contains the only list of fungi and was merely a start. Recent botanists in the State, if they had any interest at all in the fungi, were busy with pathological problems or, as in my own case, spent the bulk of the collecting season each year in other localities. It is not that the lack of data in Rhode Island makes much difference from any point of view, for the State is small and the bare spots on distribution maps are hardly noticeable. Further, the species found in Massachusetts and Connecticut are likely to be found in Rhode Island as well.

On the other hand, since it is rather generally the custom to designate distributional data by states, the mycobiota of the State of Rhode Island and Providence Plantations may as well be made known. Further, some facts of ecological importance may possibly be discovered, because there are certain features peculiar to Rhode Island besides its politics and its independence of point of view. Coniferous woods are not common in the State, more especially since the destruction of most of the white-pine stands in the 1938 hurricane, and the hardwoods are distressingly uniform in type for the most part. The higher fungi are not at all common. It is rather disconcerting even for an adopted Rhode Islander to notice that he comes across few of the larger fungi in his own state on excursion after excursion,

only to find that he begins to collect species in varying abundance as soon as he crosses the lines into Massachusetts and Connecticut. It has too often been remarked that the best way for a Rhode Islander to collect fungi is to go elsewhere.

Inasmuch as it will probably be some time before a preliminary list of Rhode Island fungi known to date can be prepared for publication, it may be of value to record here the pileate hydnumns that have thus far been collected. They are as follows with those previously reported in Bennett's list (p. 81) marked with an asterisk: **Calodon aurantiacus* (Alb. & Schw. ex Batsch) Karsten; ***C. cyaneotinctus*** (Peck) Snell, comb. nov. (det. by W. C. Coker); ?*C. scrobiculatus* (Fries) Quélet; *C. velutinus* (Fries) Quél. (det. by D. P. Rogers, confirmed by W. C. Coker); **C. zonatus* (Batsch ex Fries) Quélet; ***Dentinum albidum*** (Peck) Snell, comb. nov.; **D. repandum* (L. ex Fries) S. F. Gray; *Hydnum cristatum* Bres.; *H. fennicum* Karsten; **H. imbricatum* L. ex Fries; *H. roseolum* (Banker) Snell; *Phellodon alboniger* (Peck) Banker; *P. amicus* (Quél.) Banker; *P. graveolens* (Delast.) Banker (det. by W. C. Coker); **Steccherinum adustum* (Schw.) Banker; **S. ochraceum* (Pers. ex Fries) S. F. Gray.

In addition, Bennett's list contains the following species which have not been reported since that time: *Hydnum ferrugineum* Fries [*Calodon ferrugineus* (Fries) Quélet], perhaps, if not probably, the same as *C. scrobiculatus*; *H. subsquamosum* Batsch ex Fries & Romell, which is supposed to be the same as *H. badium* Pers., considered by Bourdot and Galzin (6, pp. 448 & 449) to be distinct from *H. imbricatum*; *H. cyathiforme* Schaeff. which Banker (1, p. 171) thinks is the same as *Phellodon tomentosus* (L. ex Fries) Banker, although Bourdot and Galzin (6, pp. 462 & 463) keep the two distinct; and *H. Erinaceus* (Bull. ex Fries) Pers.

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NOTEWORTHY SPECIES OF LEPIOTA AND LACTARIA

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(WITH 7 FIGURES)

The species of *Lepiota* described in this article were collected under Monterey Cypress trees (*Cupressus macrocarpa*) on Point Lobos which is located south of Carmel Bay in Monterey Co., California. My primary purpose in going to Point Lobos was to determine what species of *Russula* or *Lactaria* might be found growing in this habitat. However, throughout the season from October to May no species of either genus appeared. But there was an abundance of several species of *Lepiota* from February through April, most interesting of which were the following:

***Lepiota cupressea* sp. nov. (FIG. 1; 6, A)**

Pileus convex to plane, from 3.5 to 8 cm. broad; surface dry, minutely pruinose-downy at first becoming floccose to areolate outside the disc, warm sepia tone 1 with a livid tinge, to brownish-drab, becoming much paler over the marginal area as the cuticle breaks up; context quickly Etruscan red where wounded, as this disappears becoming raw umber, mild and sweet at first then slowly peppery, especially in the lamellae; margin white and minutely downy when young with the sterile edge projecting beyond the lamellae; lamellae white, fimbriate, staining first yellow then salmon, and finally sepia, free, somewhat remote, narrower at the inner end, appearing ventricose in mature specimens, unequal, a number forking near the inner end, broad, close; spores fleshy-white tone 1-2, ellipsoid, apiculate, uniguttulate, $7.5-9.5 \mu \times 4.5-5 \mu$; stipe white, becoming reddish where wounded than raw umber tone 1, minutely fibrous to floccose, bulbous, rather firm becoming hollow, 5 cm. to 7.5 cm. by .8 to 1.5 cm. at the apex and from 1.5 to 2.2 cm. through the bulb; annulus superior white becoming red where bruised then sepia, darker on the edge, hanging down and flaring out at first, then collapsing on the stipe, easily coming off if moved, otherwise persisting until mature.

Pileo primo convexo deinde plano, ab sepia (305 t-1) ad brunneum-rufum colorem (302) margine pallescente, sicco, primo pruinoso, deinde floccoso-areolato extra discum; carne rubente, postea umbrina (301), primo miti et dulci, deinde tarde acri; margine albo et subtiliter pubescente; lamellis primo albis, postea cremeis, deinde salmonicis, postremum sepiosis, remotis, inaequalibus, nonnullis ad stipitem furcatis; sporis albidulis (9 t-1 to 2), ellipsoidis, uniguttulatis, $7.5-9.5 \mu \times 4.5-5 \mu$; stipite albo, rubescente cum vul-

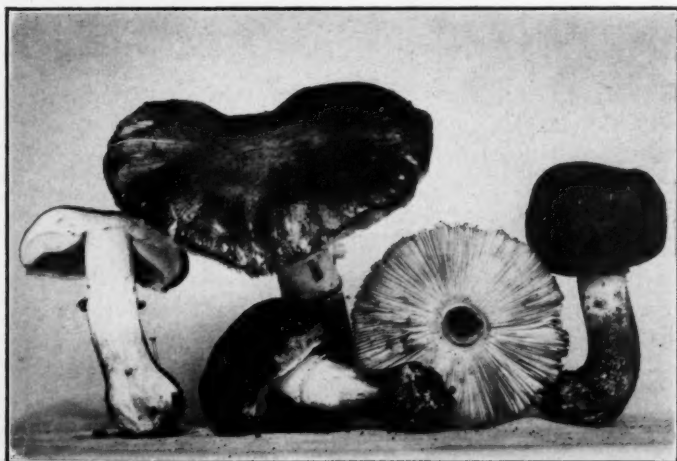


FIG. 1. *Lepiota cupressae* Burl. 4/5 nat. size.

neratus est, deinde umbrino, subtiliter fibrato-flocculoso, bulboso, firmo, postea cavo, 5-7.5 cm. \times .8-1.5 cm. ad apicem, 1.5-2.2 cm. ad basim; annulo supero, albo, sed cum vulneratus est rubescente, deinde fuliginoso et fusciori margine, pendulo et persistente.

Type locality: Point Lobos, California. Type 9 Mar. 15-1937.

Habitat: On the ground under Monterey cypress trees.

Distribution: At various places on Point Lobos and at Pacific Grove and on the Seventeen Mile Drive on the Monterey Peninsula.

This species differs from *Lepiota brunnescens* Peck in the change of wounds to red before becoming sepia and in the final peppery taste, bulbous stipe, and the size and shape of the spores and easily removable annulus. From *Lepiota americana* it differs in the surface covering of the pileus and the peppery taste; from

Lepiota Badhami in the larger spores and lack of odor, and the pendulous annulus.

***Lepiota marginata* sp. nov. (FIG. 2; 6, B)**

Pileus broadly convex becoming plane to slightly centrally depressed, tinted incarnate to pale reddish lilac with center brownish drab tone 1, surface minutely floccose over a white background, center remaining well covered with the cuticle, very slightly viscid when wet, 4 to 5.7 cm. broad; context white,

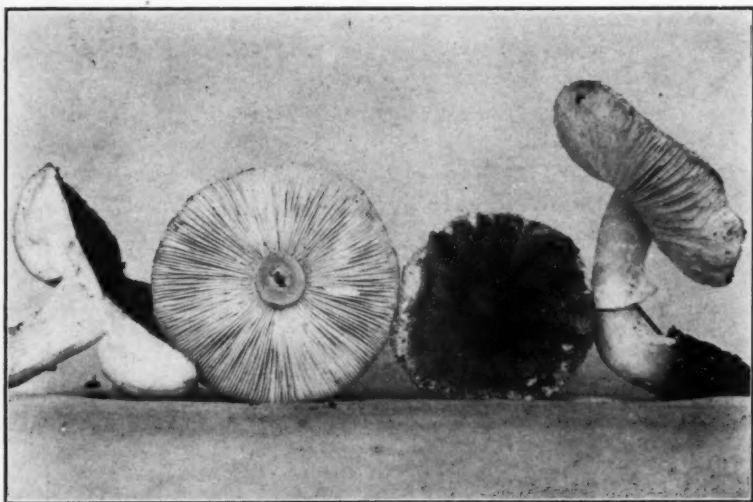


FIG. 2. *Lepiota marginata* Burl.

unchanging, taste good, odor none; lamellae white unchanging, free but not remote, broad, ventricose, minutely notched on the edge, unequal; spores white, uniguttulate, $4.3-5.3 \mu \times 6.25-7.5 \mu$; stipe white above the annulus, becoming snuff brown to burnt umber below the annulus, pruinose to floccose at the apex, a little enlarged below, becoming hollow, 3 to 5 cm. \times 1 cm. at the apex to 1 to 1.5 cm. through the base; annulus white with brownish drab to incarnate edge, median to slightly superior, hanging down close to the stipe with the lower edge flaring somewhat, 3 to 6 mm. broad, becoming movable and sometimes coming off.

Pileo primo late convexo, deinde plano aut in centro subdepresso, incarnato et in centro brunneo-rufo (302 t-1), minute floccoso sed centro cuticula integra velato, viscidulo cum udus est, 4-5.7 cm. lato; carne alba, immutabili, sapore

grato, inodora; lamellis albis, liberis sed non remotis, ventricosis, minute serratis; sporis albis, $4.3-5.3 \mu \times 6.25-7.5 \mu$; stipite albo supra annulum. brunnescente infra annulum, pruinoso-floccoso ad apicem, dilatato infra apicem, postea cavo, 3-5 cm. \times 1-1.5 cm.; annulo aut medio aut aliquantulum supero, rubro-brunneo (302) aut incarnato margine, pendulo, 3-6 mm. lato.

Type locality: Point Lobos, California.

Habitat: On the ground under Monterey cypress trees.

This species differs from *Lepiota rubrotinctoides* Murrill in the larger spores, the slightly viscid pileus and the annulus having an incarnate to brownish drab edge. The stipe below the annulus, the viscosity, and the annulus also distinguish it from *Lepiota decorata* Zeller. The specific name refers to the dark marginal line on the edge of the annulus. In well dried specimens there is a dark line at the apex of the stipe at the junction with the lamellae. The type species is number 13 April 10-1937, part of which is deposited in the herbarium of the Oregon State Agricultural College at Corvallis, and part in my herbarium.

Another species which occurred frequently is apparently close to *Lepiota decorata* Zeller and may be considered a dwarf form of that species. The pileus which varied from 3.5 to 6.5 cm. broad is densely pruinose over the center becoming floccose to minutely areolate outside the disc. When growing it is a beautiful vinaceous color fading to slate violet, but in drying the color disappears and the pileus becomes otter brown over the center and snuff brown over the remainder. The context is white and unchanging, mild and good in taste. The lamellae which are pure white, free, not remote, unequal and rarely forked become chamois color in drying. The edges are fimbriate and specimens of *Lepiota decorata* sent to me by Dr. Zeller also seem to have similar lamellae. The stipe which varies from 3 cm. to 5 cm. \times .7-1 cm. at the apex to 1.5 cm. at the base is lilac floccose over the white surface. The annulus varies from median to slightly inferior or superior, flares out with the lower edge attached, and is white and ribbed on the upper side, slate violet and downy on the under side, and becomes movable. The photograph, figure 3, is natural size. A spore drawing is shown in figure 6, C.

The species of *Lactaria* which are described were collected in Orange and Seminole counties in Florida. The distribution of

Lactaria flocculosiceps however is known to extend from Florida to Vermont.

***Lactaria fumeacolor* sp. nov. (FIG. 4; 6, D)**

Pileus fleshy, convex, centrally depressed, finally infundibuliform with extreme white-pruinose edge inrolled for some time, up to 12 cm. broad; surface fumosus to otter brown with some faint buff tone 1 to putty color in the center, or sometimes fading to that color, azonate to faintly zoned, glabrous, very viscid with



FIG. 3. *Lepiota decorata* Zell.

the cuticle separable on the margin which is entire; context white staining snuff brown to raw umber from the latex, without special odor; latex white slowly staining wounds, especially on the lamellae, first snuff brown then raw umber tone 4, slowly very peppery; lamellae fleshy-white to putty color, staining raw umber where injured, unequal, mostly simple, close, narrowed at the inner end and somewhat decurrent; stipe fleshy-white tone 4 to putty color, a little viscid, equal, 1.5-2.5 cm. \times 5-8 cm.; spores maize yellow tone 2, coarsely echinulate and reticulate banded, $8.75-10.62 \mu \times 11.25-11.87 \mu$ including the spines.

Pileo e late convexo expanso et infundibuliformi, 6-13 cm. lato, fumoso aut in disco pallidiore (311), azono aut interdum leviter zonato, viscidissimo, glabro; carne alba, brunnescenti cum vulnerata est (303-301), inódora; lacte albo, umbrino cum siccatus est, tarde acerrimo; lamellis primo subalbis tum 311, umbrinis cum vulneratae sunt (301 t-4), inaequalibus, simplicibus, adnatis deinde subdecurrentibus, confertis; stipite albidulo (9 t-4 ad 311), viscidulo; sporis pallide luteis (36 t-2), late ellipticis, echinulatis, latis lineis reticulatis, $8.75-10.62 \mu \times 11.25-11.87 \mu$.

Type locality: Kelly Park, Rock Springs, Orange Co., Florida.

Habitat: In humus under mockernut or live oaks.

Distribution: The type locality and in woods near Lake Wildmere, Longwood, Florida.



FIG. 4. *Lactaria fumea* Burl. Natural size, type 2, Apr. 3-44.

This species was collected several times during November 1941, and twice in April 1944. Evidently it will normally occur at these times. Not having collected in these localities during summer, I cannot say whether the season for the species extends from April until November. From *Lactaria trivialis* Fries and *Lactaria limacina* Beards. & Burl. it differs in the latex staining the wounds raw umber and in the occasional zonate appearance. From the latter it also differs in the absence of agglutinated tangled tomentum on the margin of the pileus and in the maize colored spores. The latex is very abundant and when the cuticle is torn from the pileus, drops exude like beads of perspiration. The type collection is number 2 Apr. 3-1944, and part of it is deposited in the New York Botanical Garden, and part in my own herbarium.

Lactaria Beardslei sp. nov. (FIG. 5; 6, E)

Pileus broadly convex expanding to infundibuliform with margin sometimes becoming striate, up to 5.3 cm. straight across; surface brownish drab becoming raw umber to chocolate, pruinose to minutely floccose, zonate, with zones fading, viscid when wet; context in stipe raw umber, paler in the pileus, with an odor when broken fresh similar to that of *Lactaria camphorata* but not persisting, slowly peppery in young specimens; latex white unchanging, slowly a little peppery in the young stage; lamellae snuff brown tone 1 to dark fawn tone 1 singly, unequal, few forking, rounded at the outer end, narrower then rounded at the

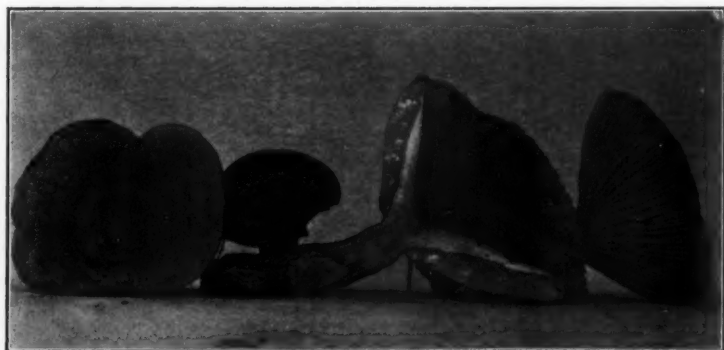


FIG. 5. *Lactaria Beardslei* Burl. Natural size, type 12, Dec. 29-43.

inner end, and attached by a decurrent tooth, rather broad, close; stipe mineral brown to brownish drab, pruinose, paler at the base and tomentose, equal to enlarged below, up to 5 cm. \times 1 cm. at the apex to 1.5 cm. at the base or from 3 cm. \times .8 cm.; spores fleshy-white, $7.5 \times 8.1 \mu$ to $8.1 \times 9.37 \mu$, protuberances of unequal length and prominent under the 1/6 power, reticulate with connecting lines when stained with iodine and viewed under higher power.

Pileo late convexo, demum expanso et infundibuliformi, 2.3-5 cm. lato, brunneo (302, 343) aut umbrino (301), obscurioribus zonis notato, expallescanti, minute pruinoso-floccoso, viscido cum udus est; margine interdum striato; carne brunnea tincta, odore grato cum fracta est, simili odoris *Lactariae camphoratae*, sed absenti cum siccata est, tarde acri; lacte albo, tarde acri cum junior est; lamellis pallide brunneis ("Brun Havane" 303 t-1 ad 307 t-1), inaequalibus, paucis ad stipitem furcatis; stipite brunneo (339 ad 302), pruinoso .8-1 cm. \times 3-5 cm.; sporis albidulis, $7.5-8.75 \mu \times 8-10 \mu$, echinulatis, reticulatis.

Type locality: Black Hammock, Oviedo, Florida.

Habitat: In rich soil rather open place in hammocks.

Distribution: Type locality and near Christmas, Florida.

This species differs from *Lactaria camphorata* (Bull.) Fries in the minutely pruinose-floccose surface which is viscid when wet, in the absence of odor in the dried state, and in the peppery taste in the fresh stage in the field, especially when young. From *Lactaria rimosella* Peck it differs in the surface being minutely pruinose-floccose rather than rimose, frequently zonate, and in the white latex. From *Lactaria helva* Fries it differs in the smaller size, frequently zonate appearance, viscosity when wet, more minute pruinose-floccose surface, lack of odor when dried, and in the habitually white latex. The color both fresh and dried is much darker. From *Lactaria mutabilis* Peck it differs in the pruinose-floccose surface of the pileus, its smaller size, the odor of the flesh, and the peppery taste of the latex in fresh young specimens.

Since the type and other collections were found in favorite collecting grounds of Prof. H. C. Beardslee, the specific name of this species seems very appropriate. Part of the type has been deposited in the New York Botanical Garden, and part remains in my herbarium.

***Lactaria flocculosiceps* sp. nov. (FIG. 6, F)**

Pileus broadly convex, umbonate, then expanding and centrally depressed with arched margin which may become crenate and striate, 2.8–6.5 cm. broad; surface fulvous to mineral brown (333 t-1), azonate, minutely tomentose becoming flocculose and paler, dry; context with a weak odor similar to that of *Lactaria camphorata* or nearly exactly like that of slippery elm (*Ulmus fulva* Michx.) when freshly broken, and remaining for some time when dried; latex watery but not like whey, a little milky in very young specimens, mild; lamellae dark fawn (307) becoming fulvous, unequal, some forking near the stipe, adnate to decurrent, close; stipe colored like the pileus or slightly paler, pruinose to villose, becoming hollow, nearly equal, 1.7–4.5 cm. long by .4–.8 cm.; spores pale blush tone 3, echinulate without lines or bands, $6.87\text{--}7.5\ \mu \times 7.5\text{--}8.75\ \mu$.

Pileo late convexo, umbonato, demum expanso et centro depresso, fulvo aut minerali-brunneo (339 t-1) azono, flocculoso, sicco, 2.8–6.5 cm. lato; margine arcuato, interdum crenato et striato; carne debili odore simili odoris

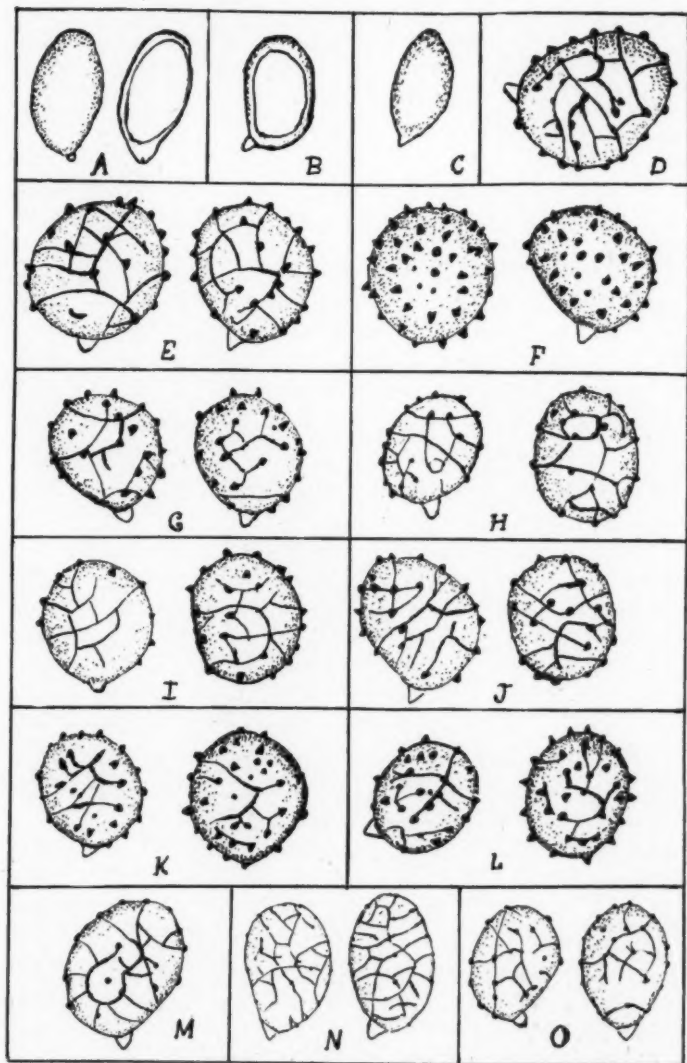


FIG. 6. Spores of A, *Lepiota cupressa*; B, *L. marginata*; C, *L. decorata*; D, *Lactaria fumeacolor*; E, *L. Beardslei*; F, *L. flocculosiceps*; G, *L. camphorata*; H, *L. helva*; I, *L. rimosella*; J, *L. mutabilis*; K, *L. alpina*; L, *L. isabellina*; M, *L. torminosa*; N, *L. floridana*; O, *L. villosa* Clem.

Lactaria camphoratae aut *Ulmi fulvae* Michx. cum fracta est et cum siccata est; lacte aqueo, aut interdum subalbo sed tenui cum junior est, miti; lamellis pileo pallidioribus (307), demum fulvis, inaequalibus, paucis ad stipitem furcatis, adnatis demum subdecurrentibus, confertis; stipite pileo concolore aut leviter pallidior, pruinoso et villosus, demum cavo; sporis *echinulatis*, $6.87-7.5 \mu \times 7.5-8.75 \mu$.

Type locality: Kelly Park, Rock Springs, Orange Co., Florida.

Habitat: Rather open places in oak woods or mixed deciduous woods.

Distribution: The type locality, also near Apopka, Longwood and Oviedo, Florida, Cold Spring Harbor, Long Island, N. Y., near Boston, Mass., and Newfane Hill, Vermont.

This species resembles *Lactaria helva* Fries in color but differs in its smaller size, rarely becoming as large as the minimum size of the former, the more minute floccose covering of the pileus and in its spores which are coarsely echinulate without lines or bands. In Studies in the Agarics of Denmark, part VII, page 35, Dr. Lange mentions collections of *L. helvus* made in 1915 as having spores without "any trace of ribs." This might indicate either insufficient staining or magnification, or that *Lactaria flocculosiceps* may occur in Denmark. From *Lactaria rimosella* Peck with which it has undoubtedly been confused, it differs in the floccose covering of the pileus rather than a rimose-areolate surface, as well as in the spore pattern and the retention of the odor for some time after the mushrooms have been dried. The spore drawings of *Lactaria camphorata* and *Lactaria helva* have been made from specimens collected in Sweden, and those of *Lactaria rimosella* Peck from type specimens.

Lactaria alpina Peck is another small species with a tomentose-squamulose pileus but without odor and with an acrid white latex. From May 30 to the middle of August 1942, this species occurred abundantly at the edge of a cluster of white birches on Newfane Hill. The squamulose appearance develops as it matures. The spore drawings are from Peck's specimens in Albany, N. Y. (FIG. 6, K; FIG. 7).

In Quelques Champignons des Hauts-Marais Tourbeux du Jura by P. Konrad and J. Favre on page 153, *Lactaria isabellina* Burl. is given as a synonym of *Lactarius tabidus* Fries. From the description of this species as given by Fries *Lactaria isabellina*

differs in the cut or broken flesh and the drying latex becoming yellow, the crowded lamellae which are not flaccid and in not wasting away as the name *tabidus* implies. Fries in *Monographia Hymenomycetum Sueciae* 2: 182. 1863, gives the taste of the latex as submild. The latex of *L. isabellina* is first *astringent* then acrid. The description of the species referred to *Lactarius tabidus* Fries by Konrad and Maublanc, cited by Konrad



FIG. 7. *Lactaria alpina* Peck.

and Favre, agrees fairly well with *Lactaria isabellina* Burl., and it is quite possible that it occurs in France and perhaps other parts of Europe. The question seems to be whether to interpolate in Fries' description characteristics which he did not include and disregard the *subdistant flaccid* lamellae, and the *wasting away* which seems to be the distinguishing feature of his species; or since Fries saw his species living and figured it, to accept his description as it stands and believe that there is a submembranaceous *Lactaria* with subdistant lamellae, white latex which is submild, not astringent, and which as a whole does *waste away* and for which the name "*tabidus*" with all it implies

would be appropriate. The spores of *Lactaria isabellina* are flesh color 67 tone 1 in mass and with iodine stain and oil immersion high power show some connecting lines between the protuberances (FIG. 6, L).

In North American Flora 9: 178. 1910, I gave *Lactaria villosa* Clem. as a synonym of *Lactaria torminosa* (Schaeff.) Pers. Since critical examination of the spores had not been made, I have recently examined them according to Crawshay's method. While they resemble the spores of *L. torminosa* in shape and in general in the ornamentation, they average somewhat smaller. However, while the spores of *L. torminosa* were from a spore print made from a specimen collected in Sweden in 1930, the spores of *L. villosa* were taken from the lamellae of specimens distributed in 1896. Unless fresh living specimens could be examined I would not wish to regard the species as distinct from *L. torminosa*. It is plainly distinct from *Lactaria floridana* Burl. in having spores which are more broadly elliptical with larger and more numerous protuberances, and a much less reticulate pattern. It is also distinct in having long tomentum projecting from the edge of the pileus as in *L. torminosa*. (Drawings of the spores of the three species recently made with the same magnification and stain are shown in figure 6, M, N, O.)

I wish to express my thanks to Dr. S. M. Zeller for specimens of *Lepiota decorata* Zell., and to Prof. Arthur T. Walker of the University of Kansas for editing the Latin descriptions.

WINTER PARK,
FLORIDA

NOTES ON FLORIDA FUNGI. III

ERDMAN WEST

(WITH 2 FIGURES)

ASCOBOLUS MAGNIFICUS Dodge.

This well-marked discomycete has been reported on horse dung from New York City and the West Indies. Typical specimens were collected on cow dung near Newman's Lake, Alachua County, on 10 September 1940. The greenish-yellow hymenium of immature specimens was in striking contrast to the brownish-black of nearly mature plants. The spore-sculpturing, a single longitudinal line, was well marked on many of the spores. There does not appear to be any previous record of the occurrence of this species in Florida (F. 23686).

DOTHICHLOE NIGRICANS (Speg.) Chardon.

This ascomycete has been collected several times in Florida during the past decade. The first collection made at Gainesville, Alachua County, 9 July 1931, was verified by W. W. Diehl. This was growing on upright stems of *Panicum hemitomon* Schult., a grass commonly called maiden cane (FIG. 1). Another collection made 27 July 1935 at Quincy in Gadsden County was on *Axonopus affinis* Chase, a pasture plant known as carpet grass. The infection is evidently systemic as all stems on the same plant are affected and show the stromata at the nodes. Flower or seed heads are not produced on infected plants (F. 2961, F. 2962, F. 2965).

PITHYA CUPRESSI (Batsch) Rehm.

Collected at Gainesville, Alachua County, 17 September 1941, by L. O. Gratz on foliage of *Cupressus* sp. This appears to be the first report of this fungus in Florida. The collection was made on a branch broken from a plant recently received from a Florida nursery. In view of this fact and the large numbers of *Cupressus* spp. and *Juniperus* spp. grown in Florida, the fungus

might be expected to be common here. That it has not been seen previously may be due in part at least to the relatively short duration of the delicate ascocarps in this warm, humid climate (F. 24306).

CINTRACTIA LIMITATA Clinton.

This is a rather inconspicuous smut that is reported as being common on *Cyperus ligularis* L. in Puerto Rico.¹ There appear to be no previous records of its occurrence anywhere else. The sedge is rather common near the coast in southern Florida but only once has it been found infected with the smut. A generous collection was made at Key West in Monroe County on 21 November 1930 (F. 15397).

CINTRACTIA MONTAGNEI (Tul.) Mag.

This inconspicuous smut was collected at Gainesville, Alachua County, on 17 June 1938 on the sedge *Rynchospora miliacea* (Lam.) A. Gray. This is a common species of sedge around flatwoods ponds but no other collections have been made on this previously unreported host. The identification of the smut was made by G. L. Zundel (F. 20442).

DOASSANSIA DEFORMANS Setch.

A collection on leaves of *Sagittaria lancifolia* L. in Orange Lake near McIntosh in Marion County was made on 2 July 1942. This fungus is not uncommon on this host in Florida but the conditions under which this particular infection occurred are rather interesting. The host is one of the dominant plants on the floating islands so common on this large, shallow, irregular lake. These islands, varying from three or four feet in diameter to thirty or forty feet, drift freely about the lake as they are blown by air currents. Their "soil" consists mostly of humus and decaying roots held together by the interlacing roots of the living vegetation. *D. deformans* has been noticed several times on *S. lancifolia* on these free-floating habitats (F. 24399).

¹ Sci. Survey of Puerto Rico and the Virgin Is. Vol. 8, part 1, p. 109. 1926.

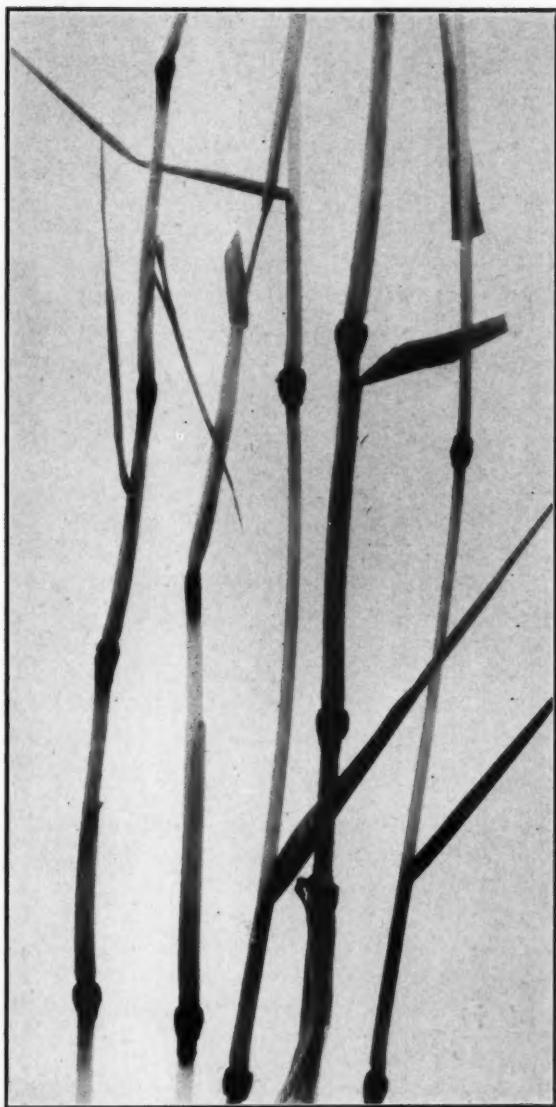


FIG. 1. *Dothichloe nigricans* on *Panicum hemitomon*.

SOROSPORIUM CONFUSUM H. S. Jackson.

Several species of the grass genus *Aristida* are very common but there are no reports of a smut on any of these in Florida. On 15 November 1941, Herman Kurz collected a specimen of *Aristida stricta* Michx. for dune-plant study and sent it to the author for determination. It exhibited more than three dozen sori of the smut, all confined to individual spikelets (F. 23674). SOROSPORIUM SYNTERISMAE (Peck) Farlow.

This widely distributed smut was collected on *Cenchrus* sp. in Manatee County by G. F. Weber, 10 November 1935, and on *C. pauciflorus* Benth. in Alachua County on 22 July 1941. Previously reported collections made in the Southeastern States include only North Carolina and Mississippi so that this is the first record from Florida (F. 21259, F. 23689).

TESTICULARIA CYPERI Klotzsch.

The existing reports of the occurrence of this conspicuous smut are few despite the fact that the original description was published over a century ago. In one northern state, New York, it was parasitizing *Rynchospora macrostachya* Torr.; in the three southern states, Texas, Louisiana and Florida, it has been reported on *R. corniculata* (Lam.) A. Gray, a very closely related species. Edgerton and Tims² indicated that the fungus was not uncommon in Louisiana. In Florida, collections have been made at a number of widely separated points since it was first collected by the late Severin Rapp in Seminole County in 1921 as reported in Lloyd's Notes.³

Collections are on file from the following counties in Florida: Alachua, Clay, Dixie, Levy, Putnam, Orange, and St. Johns. A careful search would very probably prove that the range of the smut is coextensive with that of the host, at least in Florida.

Illustrations and reports so far published tend to indicate that very few sori are produced on a single host plant. This is not true in Florida as several stems have been found each bearing over 100 sori (FIG. 2) and stems carrying 10 to 20 sori are not at all uncommon (F. 7473, F. 22706, F. 21344, F. 21343, F. 23688, F. 7472, F. 30035).

² Edgerton, C. W. and Tims, E. C. Mycologia 18: 169-170. 1926.

³ Lloyd, C. G. Myc. Notes 7: 1130. 1922.



FIG. 2. *Testicularia Cyperi* on *Rynchospora corniculata*.

USTILAGO SPHAEROGENA Burrill.

Collected on *Echinochloa crus-galli* (L.) Beauv. in the Everglades by H. H. Wedgeworth at Belle Glade, Palm Beach County, on 3 July 1931. This fairly generous collection was determined by G. L. Zundel. A very sparse collection was made on the same host along Newnan's Lake near Gainesville, Alachua County, on 30 July 1931. There are no previous reports of its occurrence in Florida (F. 7461, F. 7462).

USTILAGO TENUISPORA Ciferri.

The common smut, parasitizing the panicles of various species of *Polygonum* in Florida, has been considered to be *Ustilago utriculosa* (Nees) Tul. However a collection made 8 September 1940 in Alachua County on *Polygonum punctatum* Ell. was identified by G. L. Zundel as *Ustilago tenuispora* Ciferri. This constitutes the first record of the finding of this species in North America, all previous records being from the southern hemisphere. *U. tenuispora* differs from *U. utriculosa* chiefly in having spores only 6-8 μ in diameter instead of 9-14 μ . Study of older collections in the herbarium has revealed the fact that this species was collected in Alachua County as early as March, 1927, but not distinguished from *U. utriculosa*. Other collections indicate its wide distribution in this county, while its occurrence in other areas is proved by a collection made 20 May 1941 near Cook's Hammock in Lafayette County. All of the collections have been on the same host (F. 23762, F. 23754, F. 7401).

AECIDIUM CYRILLAE Arthur.

The geographic range of this fungus was recently⁴ extended to include two counties in Florida. While examining several large colonies of *Cyrella parvifolia* Raf. in Cook's Hammock in Lafayette County on 20 May 1941, numerous heavily infected plants were discovered. The infection was so severe on many individuals of this new host that only an occasional leaf was found free from pycnia or aecia. A few of the green twigs were found bearing aecia indicating that the fungus is occasionally caulicolous (F. 32560, F. 32561).

⁴ West, E. Mycologia 33: 40. 1941.

COLEOSPORIUM IPOMOEAE (Schw.) Burrill.

The uredia and telia of this rust are common in Florida on many species of wild morning glories. Two collections have been made on an introduced species, *Ipomoea cairica* (L.) Sweet, the first at Ruskin in Hillsborough County, 7 November 1935, by G. F. Weber and another near Vero Beach in Indian River County, 8 November 1940, by R. K. Voorhees. There appear to be no previous reports on this host in the United States. A collection made by G. F. Weber on *Ipomoea setosa* Ker. on 3 October 1923 at Gainesville in Alachua County is apparently the same species of rust (*F.* 16666, *F.* 22641, *F.* 4969).

COLEOSPORIUM LACINIARIAE Arthur.

This common rust attacks many species of *Laciniaria* in Florida. One of the largest and most conspicuous species, *L. scariosa* (L.) Hill, has not been found infected until recently, even where it was closely associated with heavily infected individuals of *L. elegans* (Walt.) Kze. and *L. laxa* (Pursh.) Kze. On 15 September 1940 several plants were found in Alachua County bearing scattered sori on both large basal and smaller upper leaves in a dry oak woods in the vicinity of longleaf pine (*F.* 22657).

COLEOSPORIUM TEREBINTHINACEAE (Schw.) Arthur.

This rust was collected inadvertently on 7 October 1940 by W. A. Murrill near Monticello in Jefferson County while obtaining specimens of *Silphium Simpsonii* Greene for the phanerogamic herbarium. This rust has not been previously reported on this host nor in Florida (*F.* 23676).

GYMNOSPORANGIUM ELLISII (Berk.) Farl.

The witches brooms caused by this rust have been observed in western Florida for many years but no colonies of the telial host, *Chamaecyparis thyoides* (L.) B.S.P., were known to occur naturally east of the Ocklocknee River until a forestry student turned up one in Putnam County nearly 200 miles farther east. A visit made to this area resulted in finding an abundance of waxmyrtle (*Myrica cerifera* L.) severely diseased and bearing great numbers of aecia on leaves and stems. This collection

was made 29 May 1942 near Interlachen in Putnam County (F. 24396).

GYMNOSPORANGIUM TRANSFORMANS (Ellis) Kern.

This rust was known only from a small group of northeastern states until reported from Florida⁵ in 1939. While visiting the group of *Chamaecyparis* in an eastern Florida county mentioned in a preceding note, the aecial stage was found on almost every specimen of *Aronia arbutifolia* (L.) Ell. that was present in the area. The shrub was not abundant but the individuals were badly diseased and in many cases severely deformed. The collection was made 29 May 1942 near Interlachen, Putnam County (F. 24395).

PUCCINIA CENCHRI D. & H.

The common rust of sandspurs is widely distributed and common in Florida on the tall sandspur, *Cenchrus echinatus* L., and has been collected occasionally on *C. pauciflorus* Benth., a host previously reported only from Oklahoma. The most robust sandspur, the coastal species, *Cenchrus tribuloides* L., has not been reported as a host of this fungus. On 27 August 1943 at Lake Worth in Palm Beach County, a colony of *C. tribuloides* on the ocean side of the dunes was found to be generally infected and a collection was obtained (F. 23268, F. 32301).

PUCCINIA EVADENS Hark.

The uredinial stage has been collected once on *Baccharis angustifolia* Michx. in Dade County, 3 September 1942. This seems to be the first record of a rust on this host although other species of *Baccharis* are commonly affected (F. 21303).

PUCCINIA FUIRENAE Cooke.

The rust on *Fuirena* has been reported on all three species of the *squarrosa* group as follows: on *F. breviseta* Cov. in Florida; on *F. hispida* Ell. in Alabama; and on *F. squarrosa* Michx. in South Carolina. The rust was recently collected again in Alachua County on *F. breviseta*. An examination of two collections in the herbarium revealed that the host was *F. hispida* Ell.,

⁵ West, E. *Mycologia* 31: 425. 1939.

and not *F. squarrosa* Michx. as indicated on the label. These collections were made at Lake City, Columbia County, on 7 August 1900 by H. H. Hume and 17 November 1900 by Lucia McCulloch (*F. 5361*, *F. 5362*).

PUCCINIA HYPTIDIS-MUTABILIS Mayor.

A common bushmint, *Hyptis mutabilis* (A. Rich.) Briq., is widely distributed in Florida and usually shows evidence of infection with a rust fungus. With the exception of pycnia, any stage or all three may be present on almost any individual of this species that is examined during the growing season. For many years this rust has been labeled *Puccinia Hyptidis* (Curt.) Tracy & Earle probably because no careful examination was made of the teliospores. These are, in all cases examined so far, definitely thickened at the apex and in most other characters correspond to those of *P. Hyptidis-mutabilis* Mayor. Collections have been in Alachua, Columbia, and Gadsden Counties. The rust on a related plant, *H. radiata* Willd. in Florida, appears to be good *P. Hyptidis* (*F. 5119*, *F. 16819*, *F. 24583*).

PUCCINIA LEONOTIDICOLA P. Henn.

The weed commonly called lion's tail (*Leonotis nepetaefolia* R. Br.) is widely distributed in Florida but despite many years of searching has never been found infected with a rust. On 8 November 1943 Arthur S. Rhoads and Phares Decker found infected leaves on nearly every plant growing in an abandoned sand-pear orchard near Ocala, Marion County. Only the uredinal stage was found in this case. The rust has been reported from the West Indies and South America but there are no previous reports from the mainland of the United States. The identification was made by Dr. George B. Cummins (*F. 7585*).

PUCCINIA LEVIS (Sacc. & Bizz.) Magn.

An introduced plant commonly called Natal grass (*Tricholaena repens* (Willd.) Hitchc.) is widely distributed in Florida especially from Gainesville southward. It has been remarkably free from fungous diseases although *Cerebella Andropogonis* Ces. is occasionally found in the seed heads. Several times during the summer of 1942, the writer found uredia of a rust on the lower

leaves of one vigorous clump. Finally on 19 August 1942, a generous collection of this stage was made but only a very few teliospores could be found.

In 1925, Frago and Ciferri ⁶ described *Uromyces Tricholaenae* on this host from Santo Domingo and described one-celled teliospores. However, Kern ⁷ after examining part of the type material was inclined to believe that the Santo Domingo rust was *P. levis*.

Part of the Florida collection was submitted to G. B. Cummins who considered it *Puccinia levis* despite the paucity of teliospores. This collection represents the first record of this rust on this host on the mainland of North America. Another collection made 5 January 1943 from the same clump of grass provided a generous quantity of teliospores, corresponding to those of *P. levis* in all respects except size. Over fifty per cent in the mounts counted measured 40–44 μ in length (*F. 28054*, *F. 24584*).

PUCCINIA OBLIQUA Berk. & Curt.

This short cycle species has been reported from the southeastern states on several members of the Asclepidaceae. In Florida it is especially common on *Seuteria palustris* (Pursh.) Vail along the seacoast. It has not been reported on *Metastelma scoparium* Nutt. but was collected on that host at Gainesville in Alachua County on 25 May 1933 and again at Key West in Monroe County on 3 November 1934 (*F. 6065*, *F. 16356*).

PUCCINIA PODOPHYLLI Schw.

The host (*Podophyllum peltatum* L.) of this rust occurs sparingly in a very few counties along the northern boundary of Florida but there is no report of the rust in this state. A generous collection of the aecial stage was made in a hammock along the Chipola River north of Marianna in Jackson County, 16 March 1937 (*F. 16370*).

PUCCINIA VIOLAE (Schum.) DC.

The rust of wild violets is widely distributed on many species of violets in the United States. It has never been found abun-

⁶ Frago and Ciferri. Bol. R. Soc. Esp. Hist. Nat. 25: 357 (1925).

⁷ Kern, F. Mycologia 20: 79. 1928.

dantly in Florida and is reported on only one species, *V. primulifolia* L., in Arthur's Manual of the Rusts. Two previously unreported hosts have been found in the vicinity of Gainesville, Alachua County. Telia were collected on *V. Walleri* House in Sanchez Hammock on 9 April 1935 and on *V. floridana* Brainerd in Sugarfoot Hammock on 13 March 1940 (0, I) and 26 June 1940 (II, III) (F. 6585, F. 17012).

UREDO CEPHALANTHI Arthur.

This rust is reported from southern Florida and Cuba. Additional Florida collections have been made in Alachua and Levy counties in the northern part of the peninsula, indicating that the range of the fungus is probably much wider than previously reported. The disease is not conspicuous on the upper surface of the leaves even when the uredia are abundant on the lower side (F. 4365, F. 21367, F. 22331).

UREDO LAETICOLOR Arthur.

This rust is recorded from the West Indies on *Ipomoea dissecta* Jacq. Several collections have been made in Florida on this same host which is widely planted as an ornamental and has become naturalized in several localities. Collections are on file from Polk County by G. F. Weber on 17 November 1923, Alachua County by the same collector on 3 November 1923, and Polk County by W. B. Tisdale on 18 June 1932. It is not uncommon in the vicinity of Gainesville, but has not been hitherto reported from Florida (F. 4370, F. 4371, F. 17117).

UREDO SAPOTAE Arthur & Johnston.

At the Subtropical Experiment Station, Homestead, Dade County, George D. Ruehle collected a rust on the leaves of seedling sapodilla trees (*Achras zapota* L.) in January 1942. This proved to be *Uredo Sapotae* Arthur & Johnston, a species hitherto reported only from the West Indies. This finding was recorded in the Plant Disease Reporter ⁸ (F. 23678).

UROMYCES COMMELINAE (Speg.) Cooke.

This rust is not uncommon in Florida on *Commelina angustifolia* Michx., an inhabitant of dry sandy regions, but it has not

⁸ Ruehle, G. D. Plant Disease Reporter 26: 261-2. 1942.

been reported on any other species. On 12 August 1942 the fungus was found infecting the leaves and stems of *C. elegans* H.B.K., a typical hammock plant, on the Campus of the University of Florida at Gainesville, Alachua County. Collections made at Cocoa in Brevard County by A. S. Rhoads on 30 June 1933 and again on 19 December 1936 appear to be on the same host. It has been previously reported on *C. elegans* only in the West Indies (*F. 23392*, *F. 24597*, *F. 16742*).

UROMYCES SPERMACOCES (Schw.) Curt.

The uredia are frequently collected in Florida on *Diodia teres* Walt., the only host reported in Arthur's Manual of the Rusts. A related plant, *Diodia tetragona* Walt., a creeping plant in moist situations, is common in many parts of Florida. *U. spermacoces* was collected on this plant 29 May 1937 near Lawtey in Bradford County, near Raiford in Union County on 22 May 1942, and in Flagler County on 25 June 1942. In contrast to the normal creeping habit of this new host, infected branches are stiffly erect and bear ascending leaves so that diseased individuals are easily distinguished in colonies of healthy plants (*F. 16804*, *F. 24397*, *F. 24401*).

Cercospora Forestierae West, sp. nov.

Maculae suborbiculares vel irregulares, 3-10 mm. in diametro, saepe confluentae, rubro-brunneae; stromatis tuberculatis, hypophyllis vel amphigenis; conidiophoris fasciculatis, brunneis, tortuosis, 1-3 geniculatis, $3-6 \times 60-120 \mu$; conidiis distincte obclavatis, ad bases fulvo-brunneis, ad apices hyalinis, pleuriseptatis, $2.5 \times 5-6 \times 85-110 \mu$.

While on a foray along the Suwannee River near Hart Springs in Gilchrist County on 1 October 1943, the common forestiera (*Forestiera acuminata* (Michx.) Poir.) was noticed to be severely diseased by a *Cercospora* leaf spot. No record was found in the literature of any species of *Cercospora* on this host. Furthermore no species of *Cercospora* reported on other members of the Oleaceae could be matched with this one on forestiera. It is therefore considered worthy of designation as a new species.

The spots are irregularly circular in shape, marginal, apical or more or less central, tawny to Dresden brown,⁹ 3-10 mm. or

⁹ Ridgway, R. Color Standards and Nomenclature, 1912.

more in diameter, coalescing to include half or more of the area of some leaves.

Mycelium internal; stroma tuberculate, hypophyllus or amphigenous; conidiophores fasciculate, dark fuscous, tortuous, 1-3-geniculate, scars prominent, 80-120 μ high, 3.5-6 μ in diameter.

Conidia mostly 85-110 μ long, some shorter, 5-6 μ thick near base, 2.5 μ towards tips, fuscous at base fading to hyaline at the tip, obclavate, rather abruptly and conspicuously enlarged below (4 or 5 cells), 7 to 11 septate (F. 2652).

SEPTORIA PACHYSANDRAE Dearness.

On 15 March 1937, a severe leaf-spotting disease of Allegheny pachysandra (*Pachysandra procumbens* Michx.) was noted in a small area of a natural stand in a hammock along the Chipola River near Marianna in Jackson County. Examination in the laboratory proved the organism associated with the spots to be a species of *Septoria*, apparently unnamed and it was so labeled. More recently this fungus has been described¹⁰ as a new species by John Dearness from collections made in Tennessee. The Florida collection extends the range of the fungus to the southern limits of its host range (F. 24605).

SIROSPHAERA CHLOROSTOMA Petch.

Three collections of this fungus growing and fruiting on various species of entomogenous fungi have been made in Florida. The first occurred at New Port Ritchey in Pasco County on 15 March 1932 where the host was cinnamon fungus, *Verticillium cinnamoneum* Petch. A second collection was obtained at Mandarin in Duval County on 13 December 1933. In this case the host was obscured by the *Sirospheera* but appears to be a species of *Aschersonia*. The third collection originated near Gainesville in Alachua County on 10 October 1939. The host is *Aegerita Webberii* Fawcett which has been mentioned by Petch¹¹ as a host for this fungus in Ceylon and Florida. There does not seem to be any record of its occurrence on *Verticillium* or *Aschersonia* (F. 10799, F. 10477, F. 22210).

¹⁰ Mycologia 33: 362. 1941.

¹¹ Petch, T. Trans. Brit. Myc. Soc. 11: 65-66. 1926.

Sirosperma floridana West, sp. nov.

Pycnidii globosis, nigris, 90–110 μ diametro, in subiculo nigro formati; parietibus pseudoparenchymatis, ostiolo nullo; conidiis hyalinis, ellipsoideis, 3.5×1.8 –2.4 μ .

Collected at Homestead in Dade County on 16 May 1933 (Type) on *Aschersonia* sp. on whiteflies on grapefruit leaves; on 8 February 1941 in the same locality on the same hosts.

During the past 10 years, a black fungus apparently parasitic on the entomogenous fungus *Aschersonia* has been collected twice on grapefruit leaves. The conspicuous olive-black patches 5–10 mm. in diameter are centered on the immature stromata of the *Aschersonia*, thinning out to an indeterminate margin as they spread over the adjacent leaf surface. When thoroughly dried, the whole patch including the *Aschersonia* and parasitized whitefly is easily detached from the leaf. Adjacent colonies coalesce and in some cases half a leaf is covered by the black fungous growth.

Near the center of the patch, minute black pycnidia are borne in great profusion but these gradually decrease in numbers toward the margin. These pycnidia are entirely superficial, seated upon a subiculum not borne in or on a stroma, nor is there any tendency for the pycnidia to coalesce. The wall of the pycnidium is thin, composed of pseudoparenchymatous cells, two layers at the top, three from about the middle to the base. The walls of the cells are dark brownish-black with no greenish color evident under the microscope.

The pycnidia are filled with hyaline one-celled spores which do not separate easily in water and are arranged in a more or less columnar manner. Their origin is not apparent for no conidiophores have been observed.

These characters fit well into the genus *Sirosperma* of Sydow of which two species have been described, both occurring on entomogenous fungi. *S. Hypocrellae* Syd., the type of the genus collected in New Guinea on *Hypocrella* sp., has spores measuring $2\text{--}3 \times 1.5 \mu$. *S. sparsum* Petch, collected in England on *Cephalosporium* sp., has spores $1.5\text{--}2 \times 1 \mu$. The spores of the Florida fungus measure 3.5×1.8 –2.4 μ .

Considering the significant deviation in spore size of the Florida fungus from those previously described, it seems desirable to consider it a new species (*F. 10478* Type, *F. 23128*).

***Sphacelia Tricholaenae* West, sp. nov.**

Carnosa, obconica vel obovoidea, albida vel cremea, circa 1 mm. alta, ex ovario graminis oriunda; sporophoris anguste clavulatis, hyalinis, dense fasciculatis, $1.2-2\ \mu$ latis; conidiis singulatim acrogenis, oblongis, hyalinis, $12-15.5 \times 5-6\ \mu$.

Hab. in floribus tricholaenae repentis.

During the late summer and fall of 1942, several patches of Natal grass (*Tricholaena repens* (Willd.) Hitchc.) in the vicinity of Gainesville were examined periodically for the presence of parasitic fungi, especially rusts, smuts and ergot. On 10 November 1942, several inflorescences were found bearing the conidial stage of a fungus, apparently *Claviceps* sp. In some panicles, more than fifty per cent of the flowers were infected but a hand lens was necessary to detect their presence because of the small size of the fungous growth and the copious hairs on the floral parts of the host. This collection was recently reported as *Sphacelia* sp.¹²

The fungous body is fleshy, obconic to obovoid, white to creamy in color. The distal portion spreads the floral parts of the grass slightly but does not extend beyond them. The conidiophores are narrowly clavate, about $1.2-2\ \mu$ wide and densely crowded together. The viscous mass of spores clings among the copious hairs on the glumes. The conidia are oblong or short cylindrical, smooth, hyaline, $12-15.5 \times 5-6\ \mu$ (*F. 32962* type).

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¹² West, E. Plant Disease Reporter 27: 113-4. 1943.

THE GENUS *LAMPRODERMA* AND ITS RELATIONSHIPS. I¹

MARY LOUISE DENNISON

(WITH 22 FIGURES)

This study of the genus *Lamproderma* was undertaken in an attempt to clarify its taxonomic position with reference to related genera in the Lamprodermaceae as well as in the Stemonitaceae, and to formulate a clearer conception of the boundaries of the genus itself and of its species. *Lamproderma* is one of many myxomycete genera whose position has often been shifted. It is also representative of those genera in which there have been many species described from time to time without adequate basis, hence many specific names have been proposed which have come to be recognized as synonyms. Meylan has described numerous species belonging to this genus. Some of them seem to be valid, some were proposed on what seems to be inadequate material and still others may be interpreted as responses to environmental conditions at the time of fruiting.

In the Myxomycetes the category *variety* has been extensively employed. It has, however, been used by so many authors to mean so many different things that it has very little value so far as this group is concerned. It has been applied to designate differences which appear to be due merely to environmental influences which, in some cases, may be associated with fluctuations in local climate, in others, with fundamental climatic difference, such as that between lowland and alpine habitats or between temperate and tropical environments. As a result, the term is highly ambiguous and might well be discarded.

The category *subspecies*, to indicate more or less constant variations which occur fairly frequently and in various localities, might well be applied to some of the forms now known as varie-

¹ This work was done in the mycological laboratory of the State University of Iowa under the direction of Professor G. W. Martin.

ties, while those differences which seem clearly to be responses to environmental influences should, if it seems necessary to designate them by names, be called *forms*. In many cases any name would seem to be superfluous and the specific description should merely be broadened to incorporate such variant fruitings.

In the treatment to follow, certain varieties described by other authors are listed as such only because of lack of material for study. In most instances it is believed that they represent fruiting responses or minor variations which merge into the typical expression of the species with which they are associated.

The study was based on the material in the herbarium of the State University of Iowa, which includes the Morgan and Wingate collections as well as numerous specimens gathered and determined by Berkeley, Bethel, Bilgram, Ellis, Farlow, F. A. Gilbert, H. C. Gilbert, Hagelstein, Harvey, Macbride, Martin, Plunkett, Rex and Shimek in North America and Brandza, Jaap, A. and G. Lister, Meylan and Sydow in Europe.

Of the thirteen species of *Lamproderma* here regarded as valid, material of seven, one of which represented part of the type collection, had been collected and determined by the authors of the species. Types or authentic specimens of several of the species here relegated to synonymy or regarded as doubtful, were also studied.

Each specimen examined was studied first macroscopically by means of a binocular microscope, then microscopic mounts were made by wetting with 95 per cent alcohol, replacing this with a 3 per cent solution of potassium hydroxide, which restores the shape and size of the spores and other structures, and examining microscopically under low power, high dry and oil immersion objectives.

Hagelstein believes that potassium hydroxide "has a tendency to alter the color of spores of certain species." In the case of *Trichia* and related genera this is often strikingly true but in *Lamproderma*, and its relatives this was not apparent except in the case of mounts allowed to stand in the KOH for several days, after which time both spores and capillitium frequently became pale. The use of freshly prepared mounts in KOH was found to be more satisfactory than that of water mounts. No dis-

coloration of spores or capillitium was observed when they were studied immediately.

In order to preserve specimens of which there was little material, permanent mounts were made in glycerine and sealed with balsam.

In the following pages the attempt is made to use certain terms consistently in describing spore markings. In order to eliminate possible confusion or misunderstanding, the specific meaning of each term, as based on Ainsworth and Bisby, "A Dictionary of the Fungi," 1943, and applied in this treatment, will be defined: punctate—marked with very small points, spots or hollows; verrucose—covered with small rounded processes or warts; echinulate—studded with small pointed processes or spines; aculeate—having long narrow spines.

The genus *Lamproderma* was proposed by Rostafinski in 1873 (Versuch 7) for species which had previously been referred to *Physarum* or *Stemonitis*. Rostafinski circumscribed his new genus adequately and placed it in what he called the tribe Stemonitaceae, with which it has been more or less associated ever since. Inasmuch as *Lamproderma* exhibits characters which indicate relationship with several other genera a short resume of the taxonomic treatment of the genus up to the present follows.

In the Versuch, the Ordo Amaurochaetae included five tribes, now regarded as families, namely, the Stemonitaceae, including the genera *Stemonitis*, *Comatricha* and *Lamproderma*, and the four monogeneric families Amaurochaetae, Echinosteliaceae, Enerthenemaceae and Brefeldiaceae. In 1874-75 Rostafinski published his monograph, followed by a supplement in 1876, but in neither of them was there any essential change made in his previous classification.

Massee, in his monograph (1892), divided the order Columelliferae into two sub-sections, or families as they are now regarded, the Stemonitae which embraced the genera *Stemonitis*, *Amaurochaete*, *Brefeldia*, *Reticularia*, *Siphoptychium* (*Tubifera*) and *Rostafinskia* (*Comatricha* in part), and the Lamprodermeae composed of *Enerthenema*, *Lamproderma*, *Echinostelium*, *Raciborskia* (*Comatricha* in part), *Orthotricha* (*Clastoderma*) and

Ancyrophorus (*Enerthenema*). The sub-sections were distinguished on the basis of the origin of the capillitium, this originating from every part of an elongated columella in the Stemonitaceae, and mainly from the apical portion of a short or elongated columella in the Lamprodermae.

Morgan (1894) distinguished the Stemonitaceae "by the brown persistent capillitium, arising from a lengthened columella, and rigidly maintaining the form of the sporangium." The genera included are *Clastoderma*, *Lamproderma*, *Comatricha*, *Stemonitis*, *Enerthenema* and *Diachea*. Of *Diachea*, Morgan states, "this genus is scarcely to be distinguished from *Lamproderma*, except by the white mass of lime which fills the tube of the stipe and columella."

Lister (1894) defined the Stemonitaceae as having stipitate sporangia with a delicate membrane, often evanescent; the stalk extending into the sporangium as a columella, from which the branching threads of the capillitium take origin. The following five genera were included: *Stemonitis*, *Comatricha*, *Enerthenema*, *Lamproderma* and *Clastoderma*. *Echinostelium* and *Raciborskia* are listed as allied genera; the latter with the suggestion that it applies to *Comatricha obtusata*. The order Amaurochaetaceae embraced the genera *Amaurochaete* and *Brefeldia* and was separated from the Stemonitaceae on the basis of the aethalial type of fruiting body.

Macbride (1899) divided the Stemonitaceae into three families, (1) the monogeneric Amaurochaetaceae, (2) the Stemonitaceae, which embraced the genera *Brefeldia*, *Stemonitis*, *Comatricha* and *Diachea*, and (3) the Lamprodermeae, which included *Enerthenema*, *Clastoderma* and *Lamproderma*.

Lister (1911) added the genus *Echinostelium* to the Stemonitaceae; Macbride (1922) added *Echinostelium* to the Lamprodermeae.

In the treatment of the Stemonitaceae in the third edition of the Lister Monograph (1925), the family is so defined as to include the genera *Barbeyella*, *Clastoderma*, *Comatricha*, *Echinostelium*, *Enerthenema*, *Lamproderma* and *Stemonitis*. Macbride and Martin (1934) include in the Stemonitaceae the genera

Amaurochaete, *Brefeldia*, *Comatricha*, *Diachea*, *Schenella* and *Stemonitis*. They recognize the family Lamprodermaceae as including those forms having a rather persistent peridium and capillitial branches arising from the apex of the columella, and embracing the genera *Barbeyella*, *Clastoderma*, *Diacheopsis*, *Echinostelium*, *Enerthenema* and *Lamproderma*.

In the Lister Monograph, *Amaurochaete* and *Brefeldia* are placed in a separate family, the Amaurochaetaceae. *Diachea* is placed in the Physaraceae because the capillitium and columella possess non-crystalline lime. *Schenella* was described in 1911 by Macbride, but was not treated in the 1922 edition of "N. A. Slime-Moulds," nor was it discussed by Lister in 1925. In Macbride and Martin this genus is placed in the Stemonitaceae. Its position is doubtful, but on the basis of its dark spores and abundant dark capillitium it may be accommodated in that family, at least temporarily. *Diacheopsis* was well described by Meylan (1930). On the basis of its membranous peridium with metallic lustre, its anastomosing capillitial filaments and its blackish purple spores, there appears to be little doubt of its affinity with *Lamproderma*.

Hagelstein (1944) follows Lister's treatment of the Stemonitaceae very closely. He includes *Clastoderma*, *Comatricha*, *Echinostelium*, *Enerthenema*, *Lamproderma* and *Macbrideola* in the family. *Barbeyella* is not treated since it has not been reported from North America. *Amaurochaete*, *Brefeldia* and *Schenella*, the latter with considerable reservation, comprise the Amaurochaetaceae. The genus *Diachea* in Hagelstein is referred to the Physaraceae in accordance with the precedent established by Lister.

It is here proposed to discard the family Lamprodermaceae of Macbride and Martin and to enlarge the Stemonitaceae so as to embrace all genera except *Echinostelium* included in the two families by Macbride and Martin, and to add to this enlarged family *Macbrideola* and *Elaeomyxa*.

Echinostelium, with its pale spores, its sparse and loosely arranged, spinose capillitium and its early loss of a peridium, should be removed from the Lamprodermaceae and placed in a

family of its own, the Echinosteliaceae, thus reviving a family established by Rostafinski in 1873. Macbride and Martin state, "*Echinostelium* may or may not belong in this family [Lamprodermaceae], but may at least be temporarily accommodated."

Hagelstein regards his new genus *Elaeomyxa* as justifying the establishment of a new family, the Elaeomyxaceae. The presence of a waxy substance in the fructification does not constitute any better reason for placing it in a family of its own when the other characters indicate relationship with the Stemonitaceae, as defined above, than the presence of lime with the combination of similar characters justifies the erection of a special family for *Diachea*. I propose therefore to incorporate this genus in the Stemonitaceae on the basis of its membranous sporangial wall, its capillitium of anastomosing and branching purplish threads, and its close resemblance to *Diachea*.

The justification for placing *Macbrideola* in the Stemonitaceae may appear a little remote. Because of its poorly developed capillitium, it suggests *Echinostelium*, which has just been removed from the family, but it has little else in common with that genus. Its undivided columella, resembling that of *Enerthenema*, its fairly persistent membranous peridium and its dark spores are evidence favoring its inclusion in the Stemonitaceae.

The Stemonitaceae as here discussed will, then, include the following genera: *Amaurochaete*, *Barbeyella*, *Brefeldia*, *Clastoderma*, *Comatricha*, *Diachea*, *Diacheopsis*, *Elaeomyxa*, *Enerthenema*, *Lamproderma*, *Macbrideola*, *Schenella*, and *Stemonitis*.

LAMPRODERMA Rost. Versuch 7. 1873.

Fructification sporangiate, stipitate or sessile, globose or ellipsoidal; peridium tough, membranous, persistent, shining with metallic iridescence; columella cylindrical or clavate, $\frac{1}{3}$ to $\frac{2}{3}$ the height of the sporangial cavity, rarely lacking; capillitium arising mainly from the apex of the columella, branching and anastomosing freely, the branches becoming more numerous and thinner as they approach the periphery; spores dark in mass.

Type: *Physarum columbinum* Pers.

KEY TO SPECIES OF LAMPRODERMA

- a. Spores reticulate over all or a portion of the surface; sporangia sessile or short stalked. b
- a. Spores not reticulate, nearly smooth, punctate, verrucose, echinulate or aculeate; sporangia sessile to long stalked. d
- b. Spores regularly reticulate with raised bands which form a border
 - 1. *L. cribrarioides*
- b. Spore reticulation various, of warts or crests. c
- c. Spores marked with large, vesicularly warted crests; capillitium pale to purplish. 2. *L. cristatum*
- c. Spores strongly verrucose, the warts frequently arranged in lines over a portion of the spore; capillitium dark, attached to the peridium by small enlargements of the tips of the filaments. 3. *L. robustum*
- d. Peridium silvery-blue, dotted with black, depressed spots
 - 4. *L. Gulielmae*
- d. Peridium iridescent, not dotted with black depressed spots. e
- e. Sessile; columella lacking; sporangiate or sometimes plasmodiocarpous. f
- e. Stalked or rarely sessile (*L. Carestiae*); columella present; sporangiate. g
- f. Spores dark brownish purple, closely echinulate, 18-19 μ
 - 5. *L. insessum*
- f. Spores blackish purple, aculeate with cylindrical spines 1 μ in length, 12-14 μ *Diacheopsis metallica*
- g. Sporangia sessile, ovate, taller than wide. 6. *L. Carestiae*
- g. Sporangia stalked, globose or depressed-globose. h
- h. Stalks short, stout. i
- h. Stalks long, slender. k
- i. Capillitium delicate, pale, flaccid, spores pale, punctate, 8-11 μ
 - 7. *L. arcyrioides*
- i. Capillitium coarse, dark throughout, rigid, spores dark, averaging a little larger. j
- j. Spores 10-12 μ , with large scattered spines, capillitium purplish brown throughout. 8. *L. muscorum*
- j. Spores 12-15 μ , echinulate, capillitium purplish, with pale tips
 - 9. *L. Sauteri*
- k. Columella dividing at apex into several main branches of the capillitium which give rise to the circinate-flexuous capillitial threads
 - 10. *L. arcyronema*
- k. Columella undivided at apex, giving rise directly to the numerous capillitial branches. l
- l. Capillitium brown throughout, not dense, freely branching and anastomosing; spores smoky-brown, punctate, 11-14 μ 11. *L. columbinum*
- l. Capillitium not brown throughout, sparsely branching and anastomosing. m
- m. Spores punctate, 7-9 μ ; capillitium typically colorless as it leaves the columella, then abruptly dark with pale tips. 12. *L. scintillans*
- m. Spores strongly aculeate, 15-20 μ ; capillitium not as above, ranging from black to colorless but tips always colorless and slender
 - 13. *L. echinulatum*

1. *LAMPRODERMA CRIBRARIOIDES* (Fries) R. E. Fries, Svensk. Bot. Tidskr. 4: 259. 1911. (FIG. 1, 12)

Stemonitis cribrarioides Fries, Syst. Myc. 3: 163. 1829.

Lamproderma lycopodii Raunk. Bot. Tidskr. 17: 90. 1888.

Fructification sporangiate, rarely plasmodiocarpous, clustered or scattered, sessile or short-stalked, diameter 0.8–1.0 mm., total height 1.0–2.0 mm.; peridium purple-brown, iridescent, membranous, wall colorless above, purplish-brown below; stalk, when present, black, often flattened or membranous, 0.1–0.6 mm. high; columella cylindrical, penetrating the sporangium $\frac{1}{2}$ – $\frac{2}{3}$ the height of sporangial cavity, absent in the plasmodiocarpous forms; capillitium a network of pale purplish-brown, flexuous threads which are stouter below, slender and colorless at the tips; spores spherical, dark purplish-brown, regularly and distinctly reticulate with narrow raised bands that form a net with from 8–24 meshes to the hemisphere and that show as a border 0.5–1.5 μ wide, 11–16 μ . Plasmodium not known.

TYPE LOCALITY: Germany.

HABITAT: On pine stumps, dead leaves and twigs and *Lycopodium*.

DISTRIBUTION: Colorado; Great Britain, Europe, Rumania. Mainly alpine.

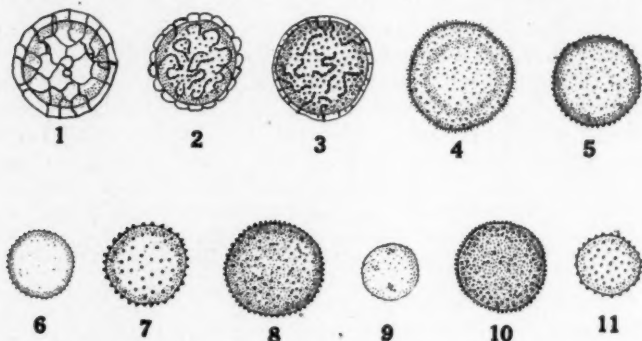
ILLUSTRATIONS: Lister (1925), *pl.* 133, *figs.* a, b, c, d, e; Macbride and Martin, *pl.* XIII, *figs.* 309, 310.

This species is easily distinguished by the large dark spores with narrow reticulate bands. G. Lister gives the spore size 11–18 μ , Raunkiaer 12–18 μ , Meylan 11–14 μ ; in the collections studied the spores were rather uniformly 14–16 μ . At first sight this species might be confused with *L. Sauteri*, but on microscopical examination the large, distinctly reticulated spores are adequate to separate it from any other *Lamproderma*. *L. cristatum* has spores with warted crests appearing more or less reticulate, and *L. robustum* has warts arranged in lines over a portion of the surface of some of the spores, but those of *L. cribrarioides* are readily distinguished from the spores of either of the other two species.

2. *LAMPRODERMA CRISTATUM* Meylan, Bull. Soc. Vaud. Sc. Nat. 53: 457. 1921. (FIG. 2, 13)

Fructification sporangiate, spherical or ovate, sessile or very short stalked, crowded or scattered, diameter 1.0–1.5 mm., total

height 1.5–2.0 mm.; peridium dark gray to iridescent, thin, membranous, evanescent; hypothallus membranous; columella cylindrical, sometimes tapering; capillitium rather pale, gray or purplish, radiating as wavy threads from the columella, frequently anastomosing, colorless at tips; spores globose, dark purplish brown in mass, purple-gray by transmitted light, marked with vesicular warted crests, 12–15 μ . Plasmodium not known.



FIGS. 1–11. Spores, from camera lucida drawings at a magnification of $\times 1500$, reduced in reproduction to $\times 1000$. Fig. 1, *Lamproderma cribrarioides*; 2, *L. cristatum*; 3, *L. robustum*; 4, *L. Gulielmae*; 5, *L. Carestiae*; 6, *L. arcyrioides*; 7, *L. muscorum*; 8, *L. Sauteri*; 9, *L. arcyriomena*; 10, *L. columbinum*; 11, *L. scintillans*.

TYPE LOCALITY: Switzerland.

HABITAT: On leaves, twigs, etc., near melting snow.

DISTRIBUTION: Known only from Switzerland.

ILLUSTRATIONS: Meylan, Bull. Soc. Vaud. Sc. Nat. 53: 457, fig. B; Lister (1925), pl. 216, fig. h; Macbride and Martin, pl. XIII, fig. 311.

This species has been collected only in the Jura Mountains by Meylan. The specimen examined was authentic material. The spores are very distinct and are unlike those of any other species in the Stemonitaceae. There is no doubt that this is a distinct species. It has not been collected thus far from the United States.

3. *LAMPRODERMA ROBUSTUM* Ellis & Ev. Bull. Washburn Lab. Nat. Hist. 1: 5. 1884. (FIG. 3, 14)

Lamproderma atrosporum Meylan, Bull. Soc. Vaud. Sc. Nat. 46: 51. 1910.

Lamproderma Sauteri Rost. var. *robustum* (Ellis & Ev.)
Graff, *Mycologia* 20: 106. 1928.

Fructification sporangiate, globose to elliptical or obovate, scattered or clustered, stipitate or sessile, diameter 1.0–1.3 mm., total height 1–2 mm.; peridium dark, purple-black with silvery sheen, fugacious, breaking up into small fragments, some of which adhere to the tips of the capillitium; stipe, when present, stout, arising from a distinct membranous hypothallus; columella cylindrical or clavate, slender, attaining one half the height of the sporangial cavity; capillitium of stout, olive-brown or black branching threads, the ends of the branches frequently obviously attached to the peridium by conspicuous enlargements; spores spherical, dark, snuff-brown, strongly and densely verrucose or reticulate by the linear arrangement of the warts over a portion of the surface of some of the spores, 12–15 μ .

TYPE LOCALITY: Mt. Paddo, Washington.

DISTRIBUTION: Washington, Oregon; as *L. atrosporum* in California, Utah, ?Quebec; Switzerland and England.

HABITAT: On woody branches and dead leaves, typically in alpine localities.

ILLUSTRATIONS: Macbride ed. 2 (1922), *pl. V, figs. 4, 4a*; as *L. atrosporum* in Lister (1925), *pl. 133, figs. f, g, h, i*, and in Macbride and Martin (1934), *pl. XIII, figs. 312, 313*.

Comparison of type material of *L. robustum* with authentic material of *L. atrosporum* from Switzerland shows them to be identical in essential respects. Both species possess to a marked degree enlargement of the tips of the capillitial branches by means of which they are attached to the peridium. This character has been held to be a unique diagnostic feature of *L. atrosporum*, but since the other, previously described species possesses it also, together with similar spore size, color and markings, as well as the same general structural and growth characteristics, it seems evident that they represent one and the same species. Since *L. robustum* is the older name it is to be retained and *L. atrosporum* is to be regarded as a synonym.

For years *L. robustum* has been associated with *L. Sauteri* from which it may be distinguished by its dark and distinctly verrucose spores which tend to exhibit some degree of reticulation and its

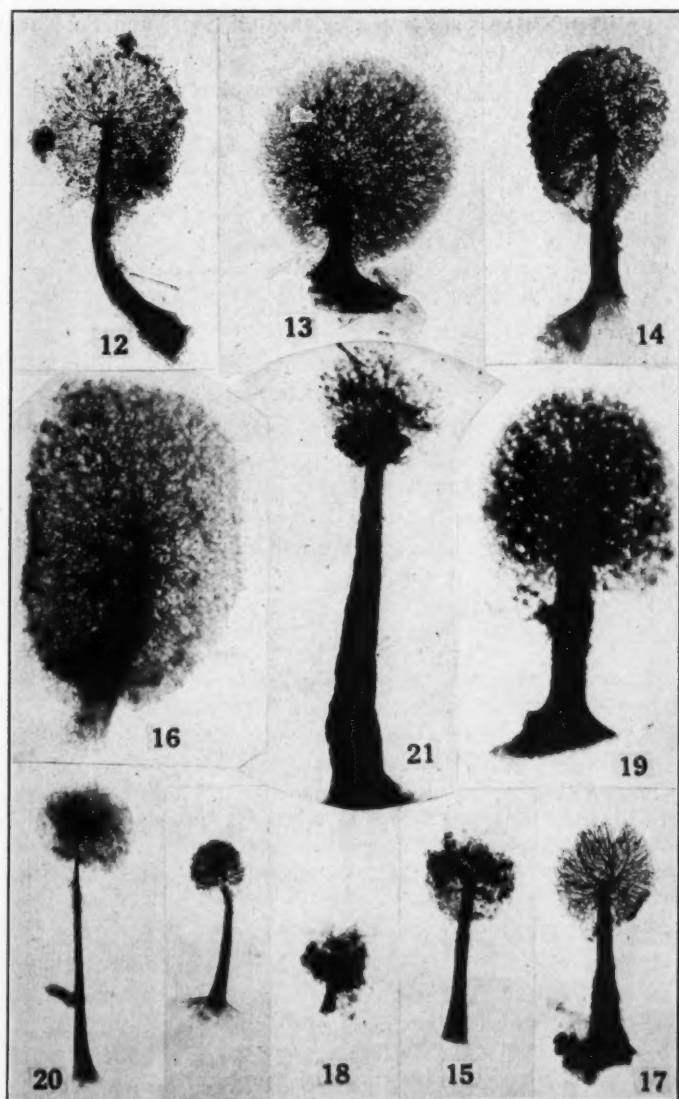
unique enlargements of the capillitial tips. The attachment of the tips of the capillitium to the peridium give to this species a diagnostic character possessed by no other *Lamproderma*. This character suggests relationship between *L. robustum* and *Clasoderma Debaryanum*.

No mention was made of *Lamproderma robustum* by Hagelstein in his recent "Mycetozoa of North America" in spite of the fact it is a species described from North America.

Lister and Howard (Jour. Bot. 57: 25. 1919) described the variety *debile* of *L. violaceum*, i.e. *L. arcyrioides* of the present treatment, with pale capillitium and pale, spinulose spores 10-11 μ . In the same article (p. 27), the variety *anglicum* of *L. atrosporum* is described with capillitial branchlets that adhere to the sporangial wall and large dark spores, more or less reticulate. A footnote appears in the article stating that Meylan suggests both forms are varieties of *L. atrosporum*. It is rather interesting to note that at this time G. Lister did not agree with Meylan, but in 1925 in the 3rd edition of the English Monograph both forms are treated as varieties of *L. atrosporum*.

No material of either of these forms was available for study. Judging entirely from the description, var. *debile* seems to resemble *L. arcyrioides* much more closely than *L. atrosporum* and if it is worthy of recognition at all, which is believed doubtful, it should be associated with *L. arcyrioides*. Var. *anglicum*, if worthy of recognition, is to be regarded as a variety of *L. robustum*, since *L. atrosporum* is a synonym of that species.

Meylan (Bull. Soc. Vaud. Sc. Nat. 57: 368. 1932) described two varieties and one form of *L. atrosporum*: var. *macrosporum* with spores 15-18 μ ; var. *echinulatum* with spores covered with long papillae; form *subcylindricum* with slender sporangia 2-3 mm. high. No material of these varieties was available for study, but on the basis of the meager descriptions it is considered very doubtful whether they represent more than growth forms which have developed in response to environmental conditions. Since the name *L. atrosporum* has been reduced to synonymy, these so-called varieties would, if recognized, be varieties of *L. robustum*, the valid name for the species.



FIGS. 12-22. Photomicrographs of sporangia $\times 24$. Fig. 12, *Lamproderma cribrarioides*; 13, *L. cristatum*; 14, *L. robustum*; 15, *L. Gulielmae*; 16, *L. Carestiae*; 17, *L. arcyrioides*; 18, *L. muscorum*; 19, *L. Sauteri*; 20, *L. arcyrionema*; 21, *L. columbinum*; 22, *L. scintillans*.

4. *LAMPRODERMA GULIELMAE* Meylan, Bull. Soc. Vaud. Sc. Nat.
52: 449. 1919. (FIG. 4, 15)

Fructification sporangiate, spherical or obovoid, loosely clustered, diameter 0.3–0.5 mm., total height 1.0–2.0 mm.; peridium bluish gray, with metallic luster, dotted with black depressed spots, some of which on dehiscence remain attached to the capillitium; stipe slender, subulate, black, 1–1.2 mm. high; columella extending to $\frac{1}{2}$ the height of the sporangial cavity; capillitium of pale brown, hyaline threads radiating from the apex of the columella; spores spherical, blackish purple, strongly echinulate, 12–15 μ . Plasmodium translucent yellow (Brandza).

TYPE LOCALITY: Switzerland.

HABITAT: On dead leaves of beech and needles of conifers.

DISTRIBUTION: Colorado; Switzerland, England, Moldavia.

ILLUSTRATIONS: Lister (1925), *pl. 215, figs. a, b, c, d*; Macbride and Martin, *pl. XIII, figs. 314, 315*; Hagelstein, *pl. 12, fig. 2*.

A unique species, recognizable at once. The black depressed spots on the otherwise silvery blue peridium distinguish it from *L. echinulatum*, in which the spores are quite similar in marking but somewhat larger in size.

The only American collections known are two from Colorado by W. C. Sturgis.

5. *LAMPRODERMA INSESSUM* G. List. Trans. Brit. Myc. Soc. 4:
41. 1912.

Fructification sporangiate, sessile, clustered, sub-globose or forming short plasmodiocarps, 0.8–1.0 mm. in diameter; peridium dark, purple-brown, with iridescent reflections, membranous; columella lacking; capillitium scanty, simple or sparingly branched, of pale purple threads, sometimes with axillary expansions and bead-like thickenings; spores spherical, dark brownish purple, closely echinulate, 18–19 μ . Plasmodium unknown.

TYPE LOCALITY: Scotland.

HABITAT: On lichen, on trunk of a living sycamore.

DISTRIBUTION: Known only from a single collection.

ILLUSTRATIONS: Lister, Trans. Brit. Myc. Soc. 4: 1912, *pl. 1, figs. 2, 2a, 2b*; Lister (1925), *pl. 215, figs. e, f*.

Lister proposed the name *Lamproderma inessum* for this species lacking a columella, but in all other respects a *Lamproderma*. The genus *Diacheopsis* was established by Meylan in 1930 to

accommodate a species closely related to *Diachea* and *Lamproderma* but likewise lacking a columella. Exteriorly it resembles *Diachea*, while its interior composition is similar to *Lamproderma*, from which it is distinguished almost entirely on the lack of a columella. One species was proposed, *Diacheopsis metallica*. Macbride and Martin suggested that *Lamproderma insessum* might be transferred to the genus *Diacheopsis*, but did not actually propose the combination.

Lamproderma insessum is slightly smaller in diameter than *Diacheopsis metallica*, its spores are closely echinulate and much larger, 18–19 μ . In growth habit, color of peridium, shape, and absence of a columella both species are obviously close, and should be regarded as congeneric.

6. *LAMPRODERMA CARESTIAE* (Ces. & de Not.) Meylan, Bull. Soc. Vaud. Sc. Nat. 57: 368. 1932. (FIG. 5, 16)

Stemonitis Carestiae Ces. & de Not. Erb. Crit. Ital. No. 88. 1879.

Lamproderma violaceum Rost. var. *Carestiae* List. Mycetozoa 130. 1894.

Lamproderma Sauteri Rost. var. *Carestiae* Meylan, Bull. Soc. Vaud. Sc. Nat. 51: 264. 1917.

Fructification sporangiate, globose or ovoid, sessile or rarely short stalked, diameter 0.9–1.3 mm.; total height 1.0–1.5 mm.; peridium violet-blue with metallic luster; columella cylindrical, about $\frac{1}{2}$ the height of the sporangial cavity; capillitium dark, purple-brown or black, colorless at tips, dense; spores spherical, dark, punctate, 10–12 μ . Plasmodium not known.

TYPE LOCALITY: Italy.

HABITAT: On turf and hollow herbaceous stalks in alpine situations.

DISTRIBUTION: Oregon, California; Scotland, Sweden, Germany, Switzerland and North Italy.

ILLUSTRATIONS: Lister (1925), *pl. 132, figs. h, i, k, l* (as *L. violaceum* var. *Carestiae*); Macbride and Martin, *pl. XIII, figs. 316, 317*.

In the English Monograph this species is regarded as a variety of *L. violaceum*, which is itself here regarded as a synonym of *L. arcyrioides*. *L. Carestiae* differs from *L. arcyrioides* by its

elongate sessile sporangia, its dense, dark capillitium and its distinctly larger spores. *L. Carestiae* is to be distinguished from *L. Sauteri* by its sessile, ovate sporangia, its dense, dark and rather rigid capillitium and its pale, smaller spores.

L. arcyrioides, *L. Sauteri* and *L. Carestiae* are quite obviously closely related but sufficiently distinct and uniform to be regarded as separate species.

7. *LAMPRODERMA ARCYRIOIDES* (Somm.) Rost. Mon. 206. 1874.
(FIG. 6, 17)

Stemonitis arcyrioides Somm. Mag. for Naturvidensk. 7: 298. 1827.

Stemonitis violacea Fries, Syst. Myc. 3: 162. 1829, not Roth 1788, nor Schum. 1803.

Lamproderma violaceum (Fries) Rost. Versuch 7. 1873.

?*Lamproderma leucosporum* Rost. Mon. App. 26. 1876.

Lamproderma nigrescens Sacc. Michelia 2: 262. 1882, not Rost. 1874.

?*Lamproderma tatricum* Racib. Hedw. 28: 117. 1889.

Lamproderma Saccardianum Massee, Mon. 101. 1892.

Tilmadoche Berkeleyi Massee, Mon. 332. 1892.

Fructification sporangiate, closely gregarious or scattered, depressed globose, somewhat umbilicate below, sessile or short stipitate, erect, diameter 0.3–1.0 mm.; total height 0.6–1.5 mm.; peridium shining with metallic blue or purple iridescent reflections; stalk, when present, stout, black, even, varying from very short to $1\frac{1}{2}$ times the height of the sporangium; hypothallus membranous, red-brown; columella cylindrical or tapering toward the apex, $\frac{1}{3}$ – $\frac{2}{3}$ the height of the sporangial cavity; capillitium of lax and flaccid, flexuous threads, branching and anastomosing to form a dense net-work, pale brown as they leave the columella, becoming pale again at the tips; spores spherical, violaceous to purplish gray, minutely punctate, 8–11 μ .

TYPE LOCALITY: Norway.

HABITAT: On old wood, decaying sticks and leaves.

DISTRIBUTION: Common in the United States; England, Scotland, Wales, France, Germany, Switzerland, Norway, Portugal, Tasmania.

ILLUSTRATIONS: Rost. Mon. pl. IV, fig. 64; Morgan, Jour. Cin. Soc. Nat. Hist. 16: pl. XI, fig. 27 (as *L. violaceum*); Lister (1925),

pl. 132, figs. a, b, c, d, e; Crowder, Nat. Geo. Mag. 49: pl. X (as *L. violaceum*); Baker, Univ. Iowa Stud. Nat. Hist. 14: pl. VI, fig. 49 (as *L. violaceum*); Macbride and Martin, pl. XIII, figs. 318, 319 (as *L. violaceum*).

This species is recognized by its pale, lax, capillitium made up of flexuous threads which anastomose freely. The capillitium tends to be pale as it leaves the columella becoming colorless at the tips. *L. scintillans* is to be distinguished from *L. arcyrioides* by its dense, rigid and sparingly branched capillitial threads, its long thin stipe and smaller but more distinctly marked spores.

In the English Monograph (1925) *L. Sauteri* and *L. Carestiae* are treated as varieties of *L. violaceum*. I regard them as distinct species and will discuss them fully as such. The name *Lamproderma violaceum* (Fries) Rost. has been generally accepted for this species. However, if the rule of priority is adhered to, it is invalid and *L. arcyrioides* becomes the valid name.

8. *LAMPRODERMA MUSCORUM* (Lév.) Hagelstein, Mycologia 27:

88. 1935. (FIG. 7, 18)

Enerthenema muscorum Lév. Ann. Sci. Nat. IV. 20: 289. 1863.

Fructification sporangiate, scattered, globose, diameter 0.3–0.5 mm., total height 0.6–1.0 mm.; peridium blue or bronze, iridescent, thin, membranous, more or less persistent at base; stalk subulate, setaceous, black, shining, about $\frac{1}{2}$ the total height, arising from a circular, purple-brown hypothallus; columella thick, tapering to the obtuse end, extending half-way into the sporangial cavity; capillitium dense, of rigid threads radiating in all directions from the apex of the columella, dichotomously forking and branching, purple-brown from base to tips; spores spherical, violet-brown, strongly echinulate, 10–12 μ . Plasmodium not known.

TYPE LOCALITY: Colombia (New Granada).

HABITAT: On dead leaves.

DISTRIBUTION: Colombia; New York and Pennsylvania.

ILLUSTRATIONS: Mycologia 27: 87 (figs. 1–3), 1935; Hagelstein (1944), pl. 4, figs. 1, 2, 3, 4.

This species is close to *L. scintillans* but is distinct by reason of its continuous, dark capillitium, its larger and coarsely echinu-

late spores and its shorter and stockier growth habit. In the latter respect it resembles *L. arcyrioides* but the spores and capillitium are completely different.

9. LAMPRODERMA SAUTERI Rost. Mon. 205. 1874. (FIG. 8, 19)
Lamproderma violaceum (Fries) Rost. var. *Sauteri* (Rost.)
List. Mycetoza 129. 1894.

Fructification sporangiate, globose to slightly flattened, umbilicate below, diameter 1–2 mm., total height 1–4 mm.; peridium dark blue, with metallic luster, not brilliant, membranous, persistent; stipe usually short, rarely exceeding the height of the sporangium, black, subulate, from a firm, well developed hypothallus; columella cylindrical, truncate $\frac{1}{2}$ height of sporangial cavity; capillitium dark, purplish or brown, threads coarse, densely branched, forming a compact network, the tips of which appear hoary after the spores are shed; spores spherical, purplish brown, echinulate 12–15 μ .

TYPE LOCALITY: Austria (Salzburg).

HABITAT: On turf and hollow herbaceous stalks, typically in alpine localities.

DISTRIBUTION: Washington, Oregon, California, Montana, Colorado, Michigan, Ontario; Scotland, Sweden, Germany, North Italy.

ILLUSTRATIONS: Rost. Mon. *pl. XIII*, fig. 5; Lister (1925), *pl. 132*, figs. *f*, *g*, *m* (as *L. violaceum* var. *Sauteri*); Macbride and Martin, *pl. XIII*, figs. 320, 321.

This species is distinguished from *L. arcyrioides* (*L. violaceum*), of which Lister regards it as a variety, by the more robust sporangia, and the larger, darker and more distinctly spinulose spores. *L. Sauteri* is distinguished from *L. Carestiae* by its stipitate habit, its coarse, purplish capillitium and its darker, echinulate spores which average a little larger.

The shape and color of the sporangia are variable characters which have led unjustifiably to the naming of new varieties of this species. Spore characters, such as size, marking and color, are considerably more constant and more emphasis should be placed upon them than on the shape and color characters of the entire fructification. Spore characters appear to be less affected by varying conditions in the environment during maturation

than external features such as color, shape and size of fructification and even than capillitial characters, and species, varieties or forms described on the basis of such superficial differences should be recognized with great caution.

In 1925 Meylan (Bull. Soc. Vaud. Sc. Nat. 56: 71) described a variety *piriforme* of *L. Sauteri* with dark spores much larger than those of the type, 15–18 μ , and spinulose. In 1932 he erected a new species, *L. ovoideum* (Bull. Soc. Vaud. Sc. Nat. 57: 373. 1932). In the same publication he states that the variety *piriforme* which he originally associated with *L. Sauteri*, has nothing in common with that species and would have been regarded as a separate species except that he already established a new species, *L. ovoideum*, of which *piriforme* could be considered a variety. A specimen from Meylan labelled *L. piriforme* was examined. In the literature available no reference to such a species can be found; it is possible that this specimen was distributed during the time Meylan was undecided as to its proper position, and that later he decided to make it a variety of *L. ovoideum*, hence never published the name *L. piriforme*. The specimen examined seems to be closer to *L. echinulatum* than to *L. Sauteri* and will be fully discussed under that species.

Four other varieties and two forms of *L. Sauteri* have been described by Meylan. They will be listed and comments concerning the distinctive features will be made in so far as is possible but unfortunately material of only one variety was available for study. Var. *brunnescens* (Bull. Soc. Vaud. Sc. Nat. 56: 325. 1927) is described as having brown or dark brown, shining sporangia, generally without iridescent reflections, pale capillitium and pale spores which are almost smooth, 9–11 μ . In the absence of any material it is impossible to discuss this variety adequately, but on the basis of the description, it is possible that it represents an aberrant form of *L. arcyrioides*, inasmuch as the characters listed, with the exception of the color of the sporangia, are remarkably similar to those of *L. arcyrioides*. Var. *atrogriseum* (Bull. Soc. Vaud. Sc. Nat. 57: 366. 1932) was described as having a dull, iron-gray peridium, and spores 15–18 μ in diameter, but the spores examined from an authentic specimen from Meylan are consistently 15 μ in size. On the basis of the

one collection seen, this variety is regarded as of doubtful significance, since it is too close to *L. Sauteri* and probably represents only a response to environmental conditions. Var. *pulchrum* (Bull. Soc. Vaud. Sc. Nat. 57: 366. 1932) is described as having a shining, metallic peridium, a denser and darker capillitium than the typical form, and spores 15–18 μ . There was no material available for study of this variety, but on the basis of its meager description, it may be regarded as doubtful. Var. *fallax* Meylan (Bull. Soc. Vaud. Sc. Nat. 58: 320. 1935) is distinguished by its whitish or slightly rose-colored capillitium. Meylan regards it as a form parallel to var. *leucotrichum* of *L. splendens*.

The two forms described by Meylan (Bull. Soc. Vaud. Sci. Nat. 57: 366. 1932) are *gracile*, with stalks exceeding somewhat the height of the sporangium, and *turbinatum*, with top-shaped sporangia. Both seem to represent growth responses, and in the absence of authentic material and on the basis of the descriptions these two forms are to be regarded as of doubtful significance.

10. LAMPRODERMA ARCYRIONEMA Rost. Mon. 208. 1874. (FIG. 9, 20)

?*Lamproderma minutum* Rost. Mon. App. 26. 1876.

?*Lamproderma suboeneum* Massee, Mon. 95. 1892.

Comatricha Shimekiana Macbride, Bull. Lab. Nat. Hist. Iowa 2: 380. 1893.

?*Lamproderma inconspicuum* Schroet. Hedw. 35: 208. 1896.

Fructification sporangiate, globose, scattered or gregarious, diameter 0.5–0.75 mm., total height 1–2.5 mm.; peridium silvery gray or bronze, iridescent, shining, thin, membranous, persistent, especially as a calyculus at base of sporangium; stipe erect, long, $\frac{2}{3}$ – $\frac{3}{4}$ total height, subulate-setaceous, slender, hairlike, rigid, black; columella cylindrical, slender, smooth, attaining $\frac{1}{3}$ – $\frac{1}{2}$ total height of sporangial cavity, then dividing into the primary branches of the capillitium; capillitium purple-brown, slender, of intricately circinate-flexuous threads, branching repeatedly and anastomosing to form a close network with few free ultimate branches; spores spherical, jet black in mass, pale violaceous by transmitted light, minutely punctate, 6–8 μ . Plasmodium watery white.

TYPE LOCALITY: Europe.

HABITAT: On dead leaves.

DISTRIBUTION: Common in United States, reported from Canada to Nicaragua, Puerto Rico, Brazil; Europe, Asia and Africa. Uncommon in England.

ILLUSTRATIONS: Bull. Lab. Nat. Hist. Iowa 2: pl. 10, figs. 3, 3a, 3b (as *Comatricha Shimekiana*); Jour. Cin. Soc. Nat. Hist. 16: pl. 11, fig. 26; Lister (1925), pl. 129; Crowder, Nat. Geog. Mag. 49: pl. 15; Baker, Univ. Iowa Stud. Nat. Hist. 14: pl. 6, fig. 48; Macbride and Martin, pl. XIII, figs. 322, 323; Hattori (1935), pl. 13, fig. 4; Hagelstein (1944), pl. 16, fig. 9.

In typical specimens this species may be readily recognized because of the peculiar apical divisions of the columella. Among *Lamprodermas* this condition is unique. Ordinarily the columella is undivided except at the apex, but specimens have been seen in which the columella branched directly above the base of the peridium. The stipe tends to be long, but varies even within a single fruiting. The spores are rather constant in size and markings, being lightly punctate all over, but sometimes with patches in which the markings appear somewhat darker and larger.

The branching of the apex of the columella of this species resembles closely that found in the columellae of several species of *Comatricha*. The two genera *Lamproderma* and *Comatricha* are admittedly closely related; however, in *Lamproderma* the peridium is consistently more persistent and shines with metallic iridescence. This constitutes, at least temporarily, a convenient means of distinguishing the two genera.

Var. *japonicum* Meylan (Bull. Soc. Vaud. Sc. Nat. 58: 323. 1935) differs from the species in its robust stature, lax capillitium and spores 8-9 μ in diameter. Lister (1925) mentions a variety similarly characterized but does not name it.

11. *LAMPRODERMA COLUMBINUM* (Pers.) Rost. Versuch 7. 1873.
(FIG. 10, 21)

Physarum columbinum Pers. Ust. Ann. Bot. 15: 5. 1795.

Trichia physaroides Schum. Enum. Pl. Saell. 2: 210. 1803.

Stemonitis physaroides Alb. & Schw. Consp. Fung. 103. 1805.

Trichia columbina (Pers.) Poiret, Lam. Encyl. 8: 52. 1808.

Fulgia encaustica Chev. Fl. Par. ed. 2, 347. 1836.

Lamproderma physaroides (Alb. & Schw.) Rost. Mon. 202. 1874.

?*Lamproderma Schimperi* Rost. Mon. 203. 1874.

Lamproderma iridescens (Berk.) Rost. Mon. App. 25. 1876.

?*Lamproderma Staszycii* Racib. Hedw. 28: 116. 1889.

Lamproderma Cruchetii Meylan, Bull. Soc. Vaud. Sc. Nat. 52: 96. 1918.

Lamproderma brevipes Meylan, Bull. Soc. Vaud. Sc. Nat. 56: 322. 1927.

Lamproderma subglobosum Meylan, Bull. Soc. Vaud. Sc. Nat. 56: 322. 1927.

Fructification sporangiate, globose or ellipsoid, scattered or gregarious, 0.5–1.0 mm. in diameter, total height 2–3 mm.; peridium rich violet or purple with metallic iridescence, membranous, persistent; stalk long, usually about $\frac{3}{4}$ the total height, black, straight, subulate; columella cylindrical with a conical apex, or clavate, $\frac{1}{3}$ – $\frac{1}{2}$ the height of the sporangial cavity; capillitium of brownish purple threads, arising from nearly all parts of the columella, rigid, sparingly forked for about $\frac{1}{2}$ – $\frac{2}{3}$ their length, then anastomosing freely to form a large-meshed open network; spores spherical, smoky-brown, punctate, 11–14 μ . Plasmodium white, rarely yellow (Lister).

TYPE LOCALITY: Europe.

HABITAT: On coniferous wood, mossy stumps, logs and rocks.

DISTRIBUTION: Common in the United States east of the Mississippi river and west of the Great Plains; British Columbia, Europe and Tasmania.

ILLUSTRATIONS: Rost. Mon. pl. IV, fig. 61; Lister (1925), pl. 191, figs. a, e, f, g, l, m; Macbride and Martin, pl. XIII, figs. 326, 327.

This species is characterized by its rich, violet-purple, iridescent peridium, its rigid capillitium of dark threads, unforked for about $\frac{1}{2}$ their length, anastomosing peripherally to form a loose-meshed network, somewhat paler in color than the rest of the capillitium, and its smoky-brown, punctate spores. The shape of the sporangium and columella, and the length of the stalk are quite variable but the spore characters appear to be constant. The brown capillitium arising from nearly all parts of

the columella and the larger, punctate brown spores distinguish it from *L. arcyrioides*. From *L. arcyronema* this species is easily distinguished by the capillitial threads which arise from all parts of the conic columella and the larger and darker spores. *L. scintillans* is distinguished from this species by its generally smaller size, its capillitium, pale as it leaves the columella, and its smaller spores.

G. Lister has described three varieties of this species. Var. *gracile* is distinguished by a long, slender, curved stalk, 5-6 times as long as the sporangium. One authentic specimen from Meylan and several specimens similar in character from the western United States have been examined critically and it is concluded that these specimens represent growth responses to environmental conditions at the time of fruiting and as such are not worthy of varietal distinction, inasmuch as they exhibit only differences of size and shape. Such differences as these are well within the realm of possibility and may occur in a single collection containing numerous individual sporangia formed from the same plasmodium. Var. *brevipes*, with short, slender stalks and dark capillitium often knotted with irregular expansions at the axils of the branches, was raised to specific status by Meylan. Referring to the three varieties *gracile*, *brevipes*, and *iridescens*, G. Lister says: "All these forms appear to merge into one another and defy attempts to divide them into distinct species." No authentic material of var. *iridescens* was available for this study. Inasmuch as G. Lister admits the three varieties of *L. columbinum* merge into one another, the validity of this variety is also open to question. It would seem advantageous to recognize them as growth forms rather than varieties.

G. Lister does not regard Meylan's species *L. Cruchetii* as worthy of specific distinction since it is based largely on plasmodial color. Other minor differences are noted by Meylan, but an examination of authentic material reveals its relationships with *L. columbinum* as too close for specific distinction.

L. subglobosum Meylan is here regarded as synonymous with *L. columbinum*; a flattened sporangium on a long stalk with a short columella is insufficient reason to give it specific rank. The spore characters are remarkably similar to *L. columbinum*.

Authentic material from Meylan was examined as well as a specimen of Brandza's from Rumania. Four specimens from Oregon were also examined which externally appeared to be *L. subglobosum*, but they too proved to be *L. columbinum*.

Lamproderma physaroides (Alb. & Schw.) Rost. is doubtfully included with *L. columbinum* by Lister. Macbride and Martin believed it to be a good species on the basis of its description by Rostafinski in his Monograph, but specimens reported as such from North America have proved to be *L. columbinum*. Hagelstein includes it with *L. columbinum* without comment. In the absence of authentic material and because the description in Macbride and Martin coincides so closely with that of *L. columbinum* I am inclined to regard the names as synonymous.

12. *LAMPRODERMA SCINTILLANS* (Berk. & Br.) Morgan, Jour. Cin. Soc. Nat. Hist. 16: 131. 1894. (FIG. 11, 22)

Stemonitis scintillans Berk. & Br. Jour. Linn. Soc. 15: 84. 1876.

Lamproderma arcyrioides (Somm.) Rost. var. *iridea* Cooke, Myx. G. B. 50. 1877.

Lamproderma irideum (Cooke) Massee, Mon. 95. 1892.

Fructification sporangiate, scattered or gregarious, globose to depressed-globose, diameter 0.3–0.5 mm., total height 1.5–2.0 mm.; peridium metallic blue-purple, brilliantly iridescent, membranous, persistent; stalk brown or black, shining, nodding or erect, long, slender, even; columella cylindrical, truncate, scarcely attaining $\frac{1}{2}$ the height of the sporangial cavity; capillitium of dense, rigid, furcate, straight, dichotomously branched brown threads which anastomose $\frac{1}{2}$ – $\frac{1}{3}$ the length of the threads and are typically colorless as they leave the columella; spores spherical, violet-gray, punctate, 7–9 μ . Plasmodium not known.

TYPE LOCALITY: Ceylon.

HABITAT: On old leaves and moss especially in early spring.

DISTRIBUTION: Common in the British Isles and Eastern United States; reported from Bolivia, Rumania, Ceylon, Japan and Java.

ILLUSTRATIONS: Morgan, *pl. XI, fig. 28*; Lister (1925), *pl. 130, figs. a, b, c, d, e, f*; Macbride and Martin, *pl. XIII, figs. 324, 325*.

The remarkable capillitium of this species constitutes an easy diagnostic character. It is very rigid and unbranched or unanastomosed until from $\frac{1}{2}$ – $\frac{2}{3}$ the distance from the columella. As compared with *L. arcyrioides* the threads are coarser and darker in color, but both species exhibit the paleness of the capillitial threads at the apex of the columella. The spores are smaller but more distinctly marked. The stalk is usually about twice as long as in *L. arcyrioides*, but this character is variable.

13. *LAMPRODERMA ECHINULATUM* (Berk.) Rost. Mon. App. 25. 1876.

Stemonitis echinulata Berk. In Hooker Fl. Tasm. 2: 268. 1860.

Lamproderma Listeri Masee, Mon. 97. 1892.

Fructification sporangiate, globose, loosely clustered, diameter 0.5–1.0 mm.; total height 2–4 mm.; peridium shining, steel-blue, with gray or green iridescence, membranous, persistent; stalk cylindrical or subulate, black, 1–2.7 mm. high; columella cylindrical, obtuse, $\frac{1}{2}$ height of sporangial cavity; capillitium arising mainly from apex of columella, stout, sparingly forked and anastomosing, purplish-brown to colorless at tips; spores spherical, dark gray or brownish purple, strongly aculeate 15–20 μ . Plasmodium opaque white.

TYPE LOCALITY: Tasmania.

HABITAT: On dead wood.

DISTRIBUTION: Tasmania, New Zealand, Sweden, England, Ireland and Japan.

ILLUSTRATIONS: Jour. Bot. 29: 1891, pl. 310, fig. 2; Lister (1925), pl. 134, figs. a–i, k; Hattori, pl. 13, fig. 6.

No material of this species was available for study, but on the basis of its description it may be regarded as valid.

A specimen from Meylan labeled *Lamproderma piriforme* was examined. No reference to such a species can be found in the literature. It is possible that this specimen is what he described as *L. ovoideum* var. *piriforme* (Bull. Soc. Vaud. Sc. Nat. 57: 373. 1932). This specimen has decidedly aculeate spores which are dark and fall well within the size range given for *L. echinulatum*, 15–18 μ . The capillitium is dark, stout, and densely branched with pale tips. The columella attains a little over $\frac{1}{2}$ the height

of the sporangial cavity, as described for *L. echinulatum*, but this is frequently a variable character in the genus. The shape of the sporangia of *L. echinulatum* is given as globose, while that of the variety under discussion is more ovate or piriforme. These two descriptions seem not to coincide too closely, but as sporangial shape is known to be a variable character and therefore not as important as the more constant and uniform spore characters they are regarded as of much less significance.

The suggestion is made here that, since *L. ovoideum* Meylan var. *piriforme* Meylan is so close to *Lamproderma echinulatum* the former named species be included in the latter, at least until material of the two forms is available for study.

DOUBTFUL SPECIES

LAMPRODERMA ECHINOSPORUM Meylan, Bull. Soc. Vaud. Sc. Nat.
55: 241. 1924.

Fructification sporangiate, spherical or ovoid, sessile or rarely stalked, 1 mm. in diameter; peridium dark brown or grayish, lacking iridescence, dull, persistent, membranous, furrowed or wrinkled; columella $\frac{1}{2}$ – $\frac{3}{4}$ the height of sporangial cavity; capillitium usually dark violaceous brown; spores spherical, purple-black, covered with pointed or obtuse spines 1 μ in length, 14–16 μ . Plasmodium not known.

TYPE LOCALITY: Switzerland.

HABITAT: On vegetable debris exposed by melting snow, high in the mountains.

DISTRIBUTION: Known only from Switzerland.

By Meylan this species is regarded as close to *L. atrosporum* (*L. robustum* of this treatment) from which it is distinguished by its persistent brown peridium, and its strongly spinulose but not reticulate spores. From *L. echinulatum* this species is said to be distinguished by its dull colors, sessile habit and somewhat smaller spores.

There was no material of this species available for study, but on the basis of the original description it seems to be very close to *L. echinulatum*, which is the older name and would be the valid one if the two are found to be the same.

LAMPRODERMA FUSCATUM Meylan, Bull. Soc. Vaud. Sc. Nat. 57:
372. 1932.

Fructification sporangiate, globose, stipitate, diameter about 1 mm., 1-1.5 mm. in total height; peridium gray, with metallic tints of blue or brown, fragile, evanescent; stalk shiny, dark brown, shorter than sporangium, on a conspicuous hypothallus; columella attaining not more than $\frac{1}{2}$ the height of sporangial cavity; capillitium dense, ferruginous; spores spherical to ovate, dark ferruginous in mass, pale by transmitted light, with a distinct lighter area on one side, punctate, 9-11 μ . Plasmodium not known.

TYPE LOCALITY: Switzerland.

HABITAT: On dead twigs.

DISTRIBUTION: Known only from Switzerland.

ILLUSTRATIONS: Bull. Soc. Vaud. Sc. Nat. 57: 370. 1932.
fig. c.

Meylan regarded this species as close to *L. atrosporum* (*L. robustum* of the present treatment) because of its fragile peridium which breaks up into fragments. Macbride and Martin suggested it was close to *L. violaceum* (*L. arcyrioides* of this treatment) with which it is obviously associated. Because the material available for study was limited to a single authentic collection, it seems advisable to consider it as a variant of *L. arcyrioides*, at least temporarily, pending further material for study.

LAMPRODERMA OVOIDEUM Meylan, Bull. Soc. Vaud. Sc. Nat. 57:
373. 1932.

Fructification sporangiate, stipitate, ovate, 1.5-2 mm. in height, 1-1.5 mm. in diameter, dark blue-black, iridescent, especially at the summit, sometimes bronze, shining; stipe short, less than half the height of the sporangium; capillitium dense, dark, brownish purple; spores spherical, dark, papillate, 13-15 μ . Plasmodium white.

TYPE LOCALITY: Switzerland.

HABITAT: On forest litter in alpine localities.

DISTRIBUTION: Known only from Switzerland.

Meylan says this species differs in every respect from *L. Carestiae*, and has in common with *L. Sauteri* only the markings of the spores. In this treatment, spore markings are regarded

as very important and more emphasis is placed on them as criteria for speciation than on external characters which are more subject to changing environmental conditions. Meylan says the spores of this species are papillate, and the spores of *L. Sauteri* are known to be echinulate. This may be a significant difference, or it may be simply a difference in interpretation of meaning of the two terms, consequently in the absence of material for verification the species is regarded as doubtful, for from the description it would seem to be very close to *L. Sauteri*.

Var. *cucumer* Meylan (Bull. Soc. Vaud. Sc. Nat. 57: 367. 1932) is unquestionably a growth form of *L. Carestiae*. The rather large, dark and indistinctly marked spores, 10-13 μ , place them together at once. The capillitial characters are also quite similar; both have a dense, dark, much branched capillitium which is pale at the tips. The shape of the sporangia is quite variable in the two collections of authentic material studied of var. *cucumer*, ranging from sessile and ovate sporangia to distinctly stalked and cylindrical or cucumber-shaped sporangia. In the authentic material of *L. Carestiae* examined the shape of the sessile sporangia ranged from globose to ovate.

It is highly possible that both the species itself, *L. ovoideum*, and the var. *cucumer* represent growth forms of *L. Carestiae* rather than *L. Sauteri* as suggested for *L. ovoideum*, but until authentic material of *L. ovoideum* is available it may be regarded from the description as close to *L. Sauteri*, while the var. *cucumer* is close to *L. Carestiae*.

In the Lister Monograph and in Hagelstein both *L. Carestiae* and *L. Sauteri* are considered as varieties of *L. violaceum*, *L. arcyrioides* of this treatment. Neither *L. ovoideum* nor its variety *cucumer* exhibit any characters which might associate them with *L. arcyrioides*. This seems to strengthen somewhat the separation of *L. Carestiae* and *L. Sauteri* as distinct species from *L. arcyrioides*.

LAMPRODERMA SPLENDENS Meylan, Bull. Soc. Vaud. Sc. Nat. 57: 44. 1929.

Fructification sporangiate, stipitate, rarely sessile, sub-spherical, not umbilicate at the base, 0.8-1.0 mm. in diameter, 1-2 mm.

in total height; peridium dark blue or bronze with brilliant, metallic luster, rarely ashy violaceous or brilliant black; stipe 0.5–0.8 mm. high, black; columella short, thick; capillitium of coarse, rigid, filaments sparsely branched in the interior, densely branched toward the periphery, or sometimes densely branched throughout; spores spherical, pale, punctate, 10–12 μ . Plasmodium white.

TYPE LOCALITY: Switzerland.

HABITAT: On plant debris, at the edge of the melting snows. Alpine.

DISTRIBUTION: Known only from Switzerland.

Critical examination of an authentic collection suggests that this species is too close to *L. Sauteri* to warrant specific distinction. It is here regarded as doubtful.

Var. *leucotrichum* was described by Meylan (Bull. Soc. Vaud. Sc. Nat. 57: 367. 1932) as having colorless capillitium appearing white.

Form *gracile* was described in the same publication as having a thin stipe, at least equal to the height of the sporangium.

LAMPRODERMA PULCHELLUM Meylan, Bull. Soc. Vaud. Sc. Nat. 57: 369. 1932.

Fructification sporangiate, sessile, or rarely short stalked, globose, 0.5–1.0 mm. in diameter; peridium dark violet-blue, iridescent, persistent; columella short, sometimes almost lacking, never over $\frac{1}{3}$ the height of the sporangial cavity; capillitium densely branched, pale rose; spores spherical, brownish purple, minutely punctate, 12–14 μ . Plasmodium unknown.

TYPE LOCALITY: Switzerland.

HABITAT: On stems of grasses, in characteristic rows. Alpine.

DISTRIBUTION: Known only from Switzerland.

This species seems to be very close to *L. Carestiae*, from which it differs only in its pale capillitium. A color difference unaccompanied by other more significant differences is not here regarded as just reason for speciation. One authentic collection was available for study. It seems justifiable to include this species in *L. Carestiae*, but pending further study and more material it is listed as doubtful.

EXCLUDED SPECIES

1. LAMPRODERMA ELLISIANA Cooke. Possibly *Comatricha laxa*, but certainly not a *Lamproderma*.
2. LAMPRODERMA FUEKELIANUM Rost. Not a *Lamproderma*. Lister says (p. 104, ed. 3) this is *Diachea subsessilis*, which is verified by her figure.
3. LAMPRODERMA HOOKERI (Berk.) Rost. Not a *Lamproderma*, possibly *Badhamia rubiginosa* var. *globosa* according to Lister (p. 19, ed. 3).

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PHLYCTOCHYTRIUM AURELIAE PARASITIZED BY RHIZOPHYDIUM CHYTRIOPHAGUM¹

LIBERO AJELLO²

(WITH 28 FIGURES)

In decaying vegetable debris collected from a quiet stream at Lake Minnewaska, Ulster County, New York, in September 1941 and June 1942 two new chytrids were found. They are of especial interest because one is parasitic upon the other, and the host is marked by unusual sporangial ornamentation. The host alone had previously been observed by Dr. Karling among material collected from the Chickahominy River in Virginia and it was recovered by the author in October 1941 and in June 1942 from a bog on Bearfort Mountain, Passaic County, New Jersey, and by Miss Hanson from material collected in Vermont in July 1942.

The parasite produces no marked hypertrophy of the host, nor does it induce septation or other abnormalities. On the contrary, the host may continue developing and produce zoospores under certain conditions even though parasitized. Death of the host seems to occur only when it is attacked early in development or by more than one parasite.

The parasitic chytrid is extramatrical, eucarpic and rhizidialeous. Its absorbing system is much reduced, consisting merely of a haustorium with two short lateral extensions. Spherical sporangia are formed which dehisce through a rupture of the sporangial wall, liberating small, uniguttulate, posteriorly uniflagellate zoospores. Golden-brown resting spores, which upon germination act as prosporangia, have also been observed. These characters place the chytrid in the genus *Rhizophyidium*

¹ The writer is indebted to Professor John S. Karling for helpful suggestions and criticism in the course of this study and to Dr. Ludwig Edelstein of The Johns Hopkins Institute of the History of Medicine for the Latin diagnoses.

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and because of its parasitic habit the specific name of *chytriophagum* has been chosen for this aquatic Phycomycete.

The host is epibiotic, monocentric and eucarpic, forming an endobiotic apophysis and a branched rhizoidal system. The inoperculate zoosporangium develops from the persistent epibiotic cyst of the zoospore. The sporangia are covered with numerous hyaline, solid, bipartite teeth. This fungus is therefore considered to be a new species of *Phlyctochytrium* and for personal reasons has been given the specific name of *Aureliae*.

Phlyctochytrium Aureliae is saprophytic, occurring on decaying vegetation and probably on the cast-off integuments of insects. This probability arises from Sparrow's (7) studies on *Asterophlyctis sarcoptoides* Petersen (3) collected in Denmark from insect exuviae. Among the irregularly stellate sporangia of *A. sarcoptoides*, which typically bear scattered over the surface several blunt, refractive protuberances, several atypical sporangia were found. These aberrant sporangia were considered by Sparrow to be either variations of the usual sporangia of *A. sarcoptoides* or the sporangia of an unknown chytrid. This latter suggestion seems to be the correct one, since the host of *Rhizophyidium chytriophagum* consistently bears bifurcated teeth and compares favorably with figure 1 k and plate 1, figure 19 in Sparrow's 1937 paper (7). The following quotation from Sparrow's book, "The Aquatic Phycomycetes" (9, p. 296), adds weight to this probability: "The form with a nearly spherical sporangium covered by small solid bipartite spines is very distinct from *Asterophlyctis sarcoptoides*, as further observations of it will no doubt reveal." No sporangia were found in our material having the stellate form and blunt protuberances typical of *A. sarcoptoides*.

Before describing the life cycle of *Rhizophyidium chytriophagum* we will further describe the host.

***Phlyctochytrium Aureliae* sp. nov.**

Sporangia extramatrical, variable in form but predominantly spherical, 12–35 μ in diameter, colorless, covered with numerous hyaline, solid, bicornute teeth, 3.5–4.5 μ long and 3.5–6.5 μ wide, single pronged teeth occasionally formed, tips of teeth at times becoming filiform and elongate, attaining lengths of 20 to 50 μ ;

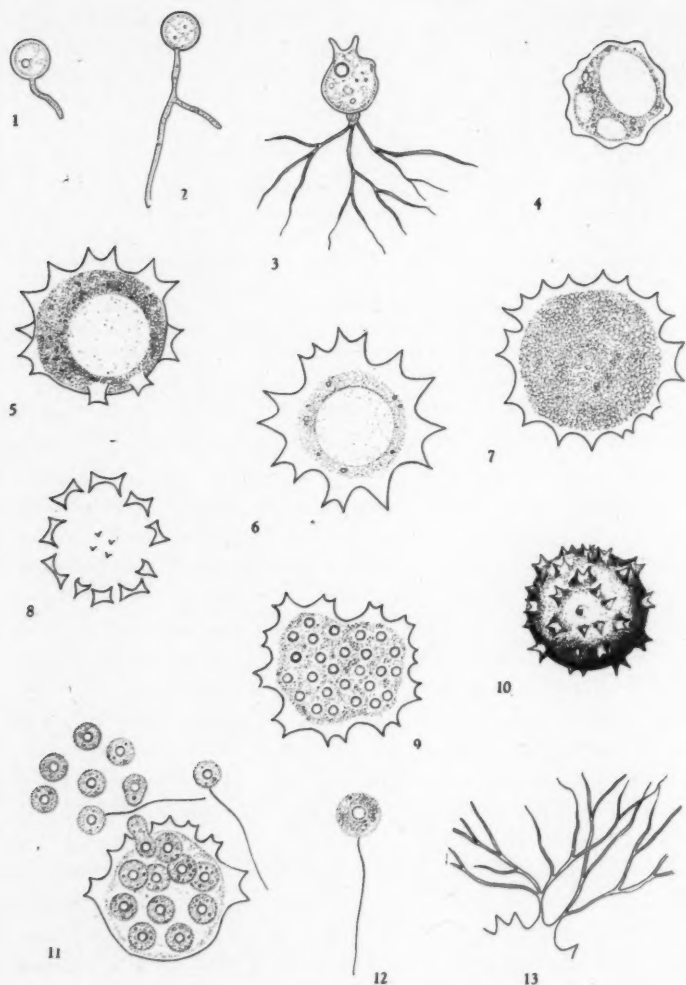
endobiotic system approximately $150\ \mu$ long consisting of a spherical apophysis, $3\text{--}7\ \mu$ in diameter, sometimes irregular or elongate with well developed rhizoids that branch profusely. Zoospores spherical, $4\text{--}4.5\ \mu$ in diameter, with a single centrally situated refractive globule, $2\ \mu$ in diameter and a single posterior flagellum, $15\text{--}20\ \mu$ long. Resting spores unknown.

Sporangia extramatricalia, formata variatim sed praecipue sphaerica, $12\text{--}35\ \mu$ diametro, incolorata, oblita dentibus permultis hyalinis solidis, $3.5\text{--}4.5\ \mu$ longis et $3.5\text{--}6.5\ \mu$ latis, quorum plurimi bicornes singuli serrati aliquando formantur et quorum summae partes, interdum redactae in formam fili, sunt elongatae crescentes in longitudinem $20\text{--}50\ \mu$; systema endobioticum circa $150\ \mu$ longum et compositum ex apophysate sphaerica $3\text{--}7\ \mu$ diametro, non numquam irregulari aut elongata, et ex rhizodeis bene perfectis et ramosissimis. Zoosporae sphaericae, $4\text{--}4.5\ \mu$ diametro, habentes singulum globulum refractivum $2\ \mu$ diametro, quod situm est in medio, et singulum posteriorem flagellum $15\text{--}20\ \mu$ longum. Sporae perdurantes non observatae.

Saprophytic on decaying vegetation and probably insect exuvia, United States and Denmark (?).

The development of *Phlyctochytrium Aureliae* is essentially similar to the other members of this genus. The thallus develops from the body of the quiescent zoospore, which produces a slender intramatrical germ tube (FIG. 1) that soon branches (FIG. 2) to form the rhizoidal system (FIG. 3). The extramatrical portion—the incipient sporangium—increases in size and concomitantly the ornamental teeth begin to appear (FIG. 3). With further development these become increasingly prominent and more numerous (FIG. 5). The rhizoidal system becomes profusely branched and complex and a swelling or apophysis is formed in that portion of the absorbing system immediately below the zoosporangium (FIG. 3). The apophysis may vary in form but is usually spherical and measures $3\text{--}7\ \mu$ in diameter. The gleaming cytoplasm of the developing sporangium contains vacuoles and numerous scattered droplets of an oil-like substance (FIG. 4). At maturity, the cytoplasm becomes densely granular and the scattered droplets coalesce to form large, more or less regularly spaced refractive globules (FIG. 9). Through cleavage the zoospores are delimited, a single globule being included in each zoospore initial.

Zoospore discharge takes place through a rupture in the sporangial wall, no definite exit papilla being formed. The zoospores

FIGS. 1-13. *Phlyctochytrium Aureliae*.

emerge en masse, remaining quiescent for varying periods of time, then becoming active and swimming away (FIG. 11). The spores are spherical with a long, trailing flagellum and contain a single, centrally situated globule (FIG. 12).

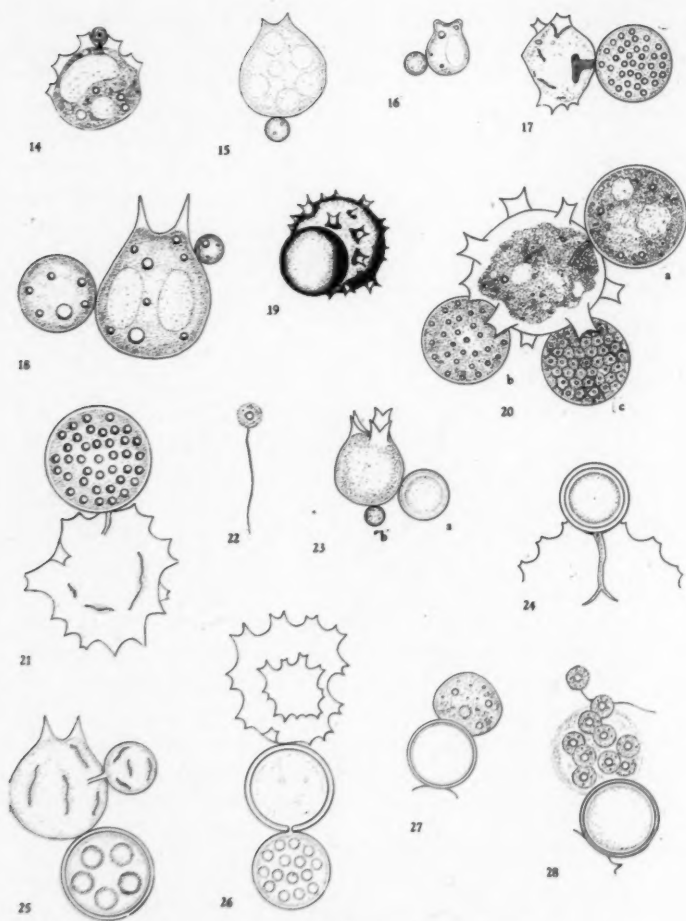
The noteworthy characteristic of *Phlyctochytrium Aureliae* is the sporangial ornamentation. Of the dentigerate species of *Phlyctochytrium*, none have their sporangial surface completely covered with bifurcated teeth. Those species bearing bipartite teeth—*P. Zygnematis* (Rosen) Schroeter, *P. dentatum* (Rosen) de Wildeman, *P. urceolare* Sparrow, and *P. dentiferum* Sparrow—have them arranged in either a single whorl or a double one. The sporangial ornaments of *P. Aureliae* are scattered over the whole surface in an apparently haphazard fashion (FIG. 10). A group of these hyaline bipartite teeth is shown in surface view in figure 8. These teeth are solid, with a concave base and incised and measure $3.5\text{--}4.5\ \mu$ in length and $3.5\text{--}6.5\ \mu$ in width. A single pronged tooth is shown with them (FIG. 8). Such unipartite teeth however are infrequently produced. Proliferation of the apices of the teeth sometimes occurs (FIG. 13). The proliferations become setigerous or thread-like and attain a length of $20\text{--}50\ \mu$. These proliferations remind one of the sporangial ornaments of *Phlyctochytrium chaetiferum* Karling (1), a chytrid which bears several long radiating and branched filaments upon the surface of the sporangium.

The haphazard grouping of the teeth of *P. Aureliae* is in contrast to the remarkable uniformity in the arrangement and number of teeth of the dentigerate species of *Phlyctochytrium*. For example, the sporangia of *P. Zygnematis* (Rosen) Schroeter bear a collarette of four bipartite teeth, and the sporangia of *P. bullatum* Sparrow are ornamented with two concentric whorls of teeth—the inner one composed of four, the outer of two.

Rhizophydium chytriphagum sp. nov.

Zoosporangia epibiotic, eucarpic, spherical, $10\text{--}30\ \mu$ in diameter, hyaline, smooth-walled, attached to the host by a tubular haustorium $4.2\text{--}7.3\ \mu$ long, $2.2\ \mu$ wide, with short lateral extensions $1.5\ \mu$ long. Zoospores spherical, $2.2\text{--}2.9\ \mu$ in diameter with a single posterior flagellum $15\ \mu$ long, and a centrally located refractive globule. Resting spores extramatrical, spherical, $6\text{--}15\ \mu$ in diameter, wall $1.4\ \mu$ thick, golden-brown in color, at germination functioning as a prosperangium.

Zoosporangia epibiotica, eucarpica, sphaerica, $10\text{--}30\ \mu$ diametro, hyalina, muro tenui, hospiti annexa tubulato haustorio $4.2\text{--}7.3\ \mu$ longo et $2.2\ \mu$ lato et brevibus extentionibus lateralibus $1.5\ \mu$ longis praedito. Zoosporae sphae-

FIGS. 14-28. *Rhizophydium chytriphagum*.

ricae, 2.2μ - 2.9μ diametro, habentes singulum posteriorem flagellum 15μ longum et globulum refractivum in medio situm. Spora perdurans extramatrix, sphaerica, 6 - 15μ diametro, muro crasso 1.4μ , colore aureo-fusco. Tempore germinationis spora est pro prosperapio.

Parasitic upon *Phlyctochytrium Aureliae* in a stream at Lake Minnewaska, Ulster County, New York.

The small zoospores of *R. chytriphagum* come in contact with a host sporangium, lose their flagellum and attach themselves to the host by means of a tubular haustorium (FIG. 14). The haustorium is extremely difficult to observe, due to the optical homogeneity of the host's and parasite's cytoplasm. But in those sporangia that are favorably situated or the contents of which are disintegrating the haustorium appears to be a tubular organ $4.2\text{--}7.3\text{ }\mu$ long and $2.2\text{ }\mu$ wide with two short lateral extensions $1.5\text{ }\mu$ long (FIG. 17). In most sporangia these details can not be observed and the haustorium, if at all observable, appears to be a simple, short tube (FIG. 20 a). As development proceeds the extramatrical spore cyst increases in size, while its contents become granular and vacuolate (FIG. 20 a). Scattered globules are present that coalesce to form the refringent globules of the zoospore initials (FIGS. 20 b and 21). The changes which take place in the maturing zoosporangia are essentially similar to those previously described for *P. Aureliae*. The sporangia are typically spherical (FIG. 19) and the mature sporangia vary in size from 10 to $30\text{ }\mu$. After cleavage (FIG. 20 c), the zoospores emerge through a rupture in the sporangial wall, forming a quiescent mass at the exit site. The mass soon disperses, the individual zoospores swimming away with the characteristic darting motion of chytrid spores. These zoospores are small, measuring $2.2\text{--}2.9\text{ }\mu$ in diameter and bearing a single posteriorly attached flagellum $15\text{ }\mu$ long (FIG. 22). A single centrally situated refractive globule, $1.2\text{ }\mu$ in diameter, is present.

Golden-brown resting spores were readily formed by the parasite and all stages in their development and germination were observed. These spores are spherical and vary from $6\text{ }\mu$ in diameter to $15\text{ }\mu$ (FIG. 24). The wall is thick, $1.4\text{ }\mu$ and smooth. A single, large refractive globule is found in the resting spore, although it may sometimes be surrounded by several smaller ones. A short haustorium similar to the absorbing system of the vegetative zoosporangium comprises the absorbing system of the resting spore (FIG. 24).

The resting spores begin their development in a manner similar to that of the zoosporangia but very shortly the amount of refractive material increases. So much so, that the incipient

resting spores may generally be recognized through the presence of large amounts of refractive material in the cytoplasm (FIG. 23 a). Later stages in development in which the refractive globules have increased considerably in size and number and the wall has begun to thicken are shown in figure 25. With further development the refractive globules coalesce and form a single large one and the wall thickens further as shown in figure 24. As these changes occur the resting sporangium assumes a deep golden-brown color. Sexuality does not appear to be involved in the resting spore formation of *R. chytriphagum*.

Preparations for germination involve a gradual breaking down of the usually single refractive globule and its dispersal throughout the cytoplasm. At this stage a small germ pore is formed in the thick wall of the resting spore and its contents confined in a vesicle emerge through this pore (FIGS. 26 and 27). The vesicle forms the evanescent sporangium where further differentiation of the cytoplasm takes place (FIG. 26). The contents undergo cleavage and the zoospores escape through a rupture in the thin sporangial wall (FIG. 28). These zoospores are similar in size, form and activity to those formed by the vegetative zoosporangia. They, too, are capable of parasitizing sporangia of *Phlyctochytrium Aureliae*.

The literature reveals at least five chytrid hyperparasites that are extramatrical, eucarpic and rhizidiaceous: *Rhizophyidium parasitans* Scherffel (4), *Phlyctochytrium Synchytrii* Köhler (2), *Septosperma anomola* (Couch) Whiffen (10), *Septosperma Rhizophidii* Whiffen (10), and *Phlyctidium Dangeardii* Serbinow (6). The parasite of *Phlyctochytrium Aureliae* is of this nature but differs in many respects from these rhizidiaceous hyperparasites.

Rhizophyidium parasitans Scherffel (4), which is listed by Sparrow (9) among the imperfectly known species of *Rhizophyidium*, forms spherical sporangia 8–10 μ in diameter, zoospores measuring 4 μ in diameter with a flagellum 24 μ long and an eccentrically placed refractive globule. *R. chytriphagum* produces sporangia 12–30 μ in diameter, zoospores measuring 2.2–2.9 μ in diameter with a flagellum 15 μ long and a centrally placed refractive globule. The most striking difference between these two species is found in the resting spores. Those of *R. parasitans* are described

as being $6\ \mu$ in diameter with a thick, smooth colorless wall. Germination was not observed. The resting spores of *R. chytriphagum*, on the other hand, range in size from $6\text{--}15\ \mu$ in diameter and are golden-brown in color. Upon germination they function as prosperangia.

The sessile sporangium of *Phlyctochytrium Synchytrii* Köhler (2) is apophysate and bears several exit papillae. *Rhizophyidium chytriphagum* forms no definite exit papillae and is non-apophysate. The resting spores of *P. Synchytrii* are colorless and $14\ \mu$ in diameter. They, too, function as prosperangia on germination.

The two species of *Septosperma* (10) are quite distinct from *R. chytriphagum* in that their resting spores are bipartite, consisting of an empty basal portion and an apical portion which contains cytoplasm. Germination of these spores was not observed.

Phlyctidium Dangeardii Serbinow (6) is another imperfectly known hyperparasite. Sparrow (9) suggests that it may very well be a species of *Rozella*. Serbinow described it as forming small, ovoid zoospores $1.5\ \mu$ long. Dehiscence occurs through a sessile apical pore. The resting spores are thick-walled with an undulating outer wall. Germination was not observed. No rhizoid or haustorium was figured.

From these descriptions it is evident that *Rhizophyidium chytriphagum* is to be considered a new species.

SUMMARY—*Rhizophyidium chytriphagum* was found parasitizing the sporangia of *Phlyctochytrium Aureliae* collected at Lake Minnewaska, Ulster County, New York. The epibiotic sporangia are spherical and are attached to the host by means of a short, tubular haustorium with two short lateral extensions. Thick-walled, golden-brown resting spores are formed which upon germination act as prosperangia. The parasite has little or no adverse effects upon the host unless more than one parasite attacks the host or if infection occurs early in the host's development.

The host, *Phlyctochytrium Aureliae*, forms sporangia covered with numerous solid, bipartite teeth, arranged in an apparently haphazard order. It is saprophytic, occurring on decaying vegetation and probably on the cast off integuments of insects. It

has been found in New York, New Jersey, Vermont, Virginia and possibly in Denmark.

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EXPLANATION OF FIGURES

FIGS. 1-13. *Phlyctochytrium Aureliae*. Fig. 1, germinating zoospore; 2, later stage in germination showing branched germ tube; 3, immature sporangium showing development of teeth, apophysis, and rhizoidal system; 4, median optical view of young zoosporangium showing vacuoles and granular cytoplasm; 5 & 6, median optical views of maturing sporangia showing development of teeth and vacuolate cytoplasm; 7, median optical view of older zoosporangium with undifferentiated cytoplasm; 8, surface view of a cluster of bipartite teeth with occasional unipartite teeth; 9, median optical view of mature sporangium with refractive globules; 10, three dimensional surface view of mature zoosporangium; 11, median optical view of sporangium discharging zoospores; 12, zoospore with central refractive globule; 13, proliferation of teeth apices. Fig. 4, $\times 4,000$. Fig. 8, $\times 1,750$. All others, $\times 3,000$.

FIGS. 14-28. *Rhizophydium chytriphagum*. Fig. 14, germ tube of parasite penetrating host; 15, 16 & 18, sporangia of *Phlyctochytrium Aureliae* infected by *Rhizophydium chytriphagum*; 17, median optical view of parasite's haustorium in empty host sporangium; 19, three dimensional view of mature parasite sporangium and host; 20, median optical view of heavily infected host sporangium; 20a, immature vacuolate sporangium of parasite with peg-like haustorium; 20b, refractive globules in cytoplasm of developing parasite sporangium; 20c, parasite sporangium showing cleavage of cytoplasm into zoospore initials; 21, empty host sporangium showing developing parasite sporangium and penetration of haustorium; 22, zoospore of *Rhizophydium chytriphagum*; 23a, incipient resting spore of parasite infecting *Phlyctochytrium Aureliae*; 23b, young parasite; 24, mature resting spore showing thick wall, large refractive globule and forked haustorium; 25, resting spore with several refractive globules developing at the expense of host and second parasite; 26, germinated resting spore showing differentiated secondary sporangium; 27, germination of resting spore with contents emerging in a vesicle; 28, zoospore discharge from evanescent sporangium derived from resting spore. Figs. 14-16, 18, 22, 25 and 28, $\times 4,000$. Figs. 17, 19-21, 23, 24, 26 and 27, $\times 3,000$.

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A NEW DESERT COPRINUS

WILLIAM H. LONG AND VERA MENTZER MILLER

(WITH 3 FIGURES)

While on a field trip searching for *Tylostoma*, the senior author discovered a unique agaric herein described as a new *Coprinus*. The outstanding character of the species is the star-shaped remnant of the universal veil which occupies the center of the pileus. Other *Coprini* show veil remnants on the cap, but in no other species examined has there ever been a structure as concrete as there is on this material.

The following description was made from dry material as no fresh plants were available.

Coprinus asterophorus sp. nov.

Sporophoro hypogaeo usque ad maturitatem deinde erumpente. *Pileo* convexo demum subplano, 3-6 cm. lato, reliquiis veli universalis in forma astri conspicuis ornato. *Carne* membranacea. *Lamellis* liberissimis. *Stipite* 5-11 cm. longo, 3-5 mm. crasso, solido deinde cavo. *Annulo* nullo. *Volva* adnata, margine libere angusto. *Sporis* nigris, levibus, ovatis, $14-20 \times 10-12.7 \mu$. *Basidiis* tetrasporis, $29-48 \times 10-15 \mu$.

Sporophore hypogaeous until maturity, then erumpent, originating 2-3 cm. below the surface of the soil, having a well developed universal veil. *Pileus* 3-6 cm. broad, tissue not distinct from that of the stipe, at first obtusely conical expanding to almost plane, with a central sterile disc 6-12 mm. across to which the gills are attached, very young buttons not seen, but ones with gills still white and caps 1.5 cm. broad and 1.2 cm. tall were examined. The expanded pilei have gills connected by an extremely thin, black membrane with fine, light-colored, raised, sandy radial lines or ribs marking the position of the gills on the opposite side. *Cuticle* ripped into fragments by the shrinkage of the volva patch and when the pileus expands, showing as very narrow radiating lines on the naked black context (FIG. 1-2) or clinging to the edges of the volval patch in the angles of the arms; in some cases no signs of the cuticle are left on the pileus (FIG. 3). Fragments of the cuticle, Tilleul-buff when dry. *Context* membraniform. *Gills* white, becoming black, semideliques-

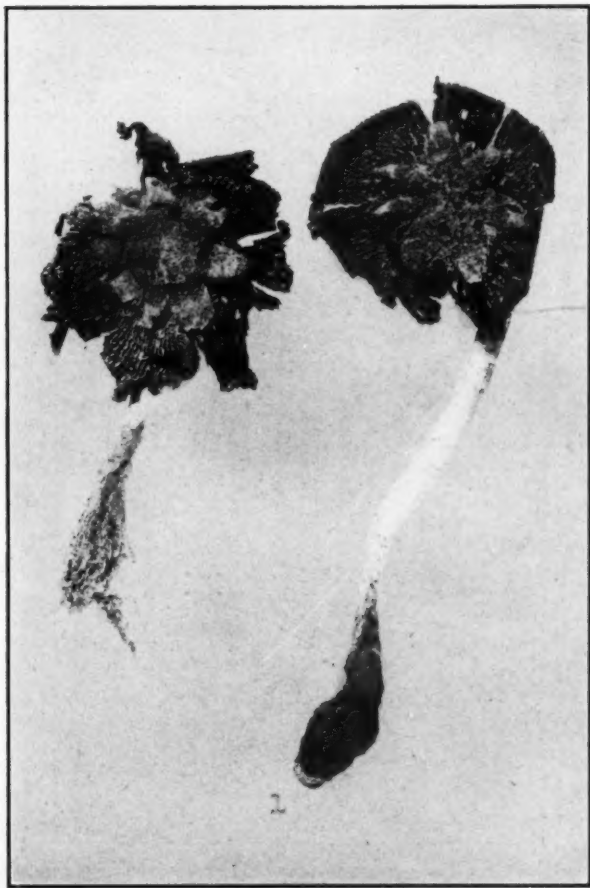


FIG. 1. *Coprinus asterophorus*, mature sporophore showing stellate volva patch and radiating fragments of the cuticle, $\times 1$.

cent, thin, lamellate, radially arranged, close, free, remote from stipe, arcuate at first, then plane, equal throughout, narrow, 1-2 mm. broad (dried), rounded behind, gills of mature specimens connected to one another on the back edge by an onion-skin-thin membrane, on weathering and deliquescing the gills may become free and spread away from each other, twisted, shriveled, giving the frayed appearance one often sees in the older stages of other

Coprini. *Stipe* equal, 5–11 cm. long, 3–5 mm. thick, terminating in a bulbous base (FIG. 1 & 3), at first white-cottony inside, becoming entirely hollow and consisting only of a tough, thin outer wall, flexible when dry, white at first then buff-colored, exannulate, not woody as in *Montagnites*, exterior not splitting, surface

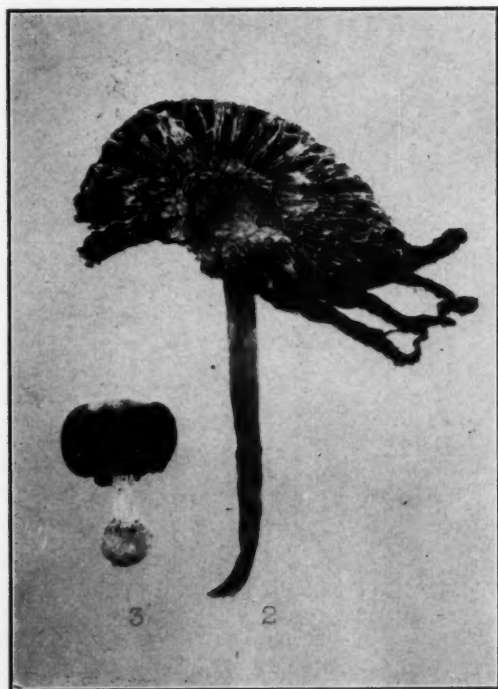


FIG. 2. *Coprinus asterophorus*, expanded pileus, showing radiating fragments of the cuticle, arms of volva patch broken off, $\times 1$. FIG. 3. *Coprinus asterophorus*, showing freshly emerged plant with conical unexpanded pileus, no cuticle left; the stellate volva cap was present but fell off from handling $\times 1$.

longitudinally appressed fibrillose, with a crinkled undulate appearance when dry. *Bulb* rounded to obtusely pointed, 5–8 mm. broad, solid, entirely sand-covered. *Volva* apparently glutinous before emergence as evidenced by the firmly attached grains of sand, circumscissile, adnate below, with a narrow free limb at top of the bulb, balance of volva remaining on top of pileus as a permanent adhering patch 2–4 cm. broad, soon splitting into 7–10

blunt or acute divisions 6–15 mm. long, the main body of the volva patch covering the disk, but the arms of the star extending halfway to the margin of the pileus, crustose, warted, very sandy, honey-yellow to chamois (Ridgway), easily removable although persistent in the oldest specimens, tissue consisting of closely compacted prosenchyma cells $7.6\text{--}12.7\ \mu$ broad. Spores $14\text{--}20 \times 10\text{--}12.7\ \mu$, ovate to oblong, dark brown under high power (dry), black in mass when viewed with naked eye, smooth, with a large pore at smaller end, minutely apiculate at opposite end. Basidia $29\text{--}48 \times 10\text{--}15\ \mu$, clavate, 4-spored. Cystidia none. Trama of gills narrow, cells rounded.

HABITAT: Solitary or in groups of 2–8 individuals, in open unshaded areas in infertile sandy soil, or in red volcanic soil.

RANGE: Central Arizona, central to southern New Mexico, with a range in altitude from 3400 to 5000 feet.

DISTRIBUTION: New Mexico. Bernalillo County: in an old cow pasture 2 miles south of the Alameda Bridge on the west side of the Rio Grande river, elevation 5000 feet, March 7, 1941, *W. H. Long* 9305 (2 plants); 4 miles north of Albuquerque on Highway 85, elevation 5000 feet, June 10, 1941, *W. H. Long* 9343 (3 plants); 4 miles north of Albuquerque on Guadalupe Trail on west end of the Denton Addition, June 12, 1941, *W. H. Long* 9354 (type) (5 plants); 3 miles north of Albuquerque on Highway 85, June 11, 1940, May 28, 1941, May 24, 1942, *W. H. Long* 10427 (1 plant), 9355 (1 plant), 10251 (1 plant). Chavez County: in oak shinnery (*Quercus Harwardii*), 34 miles east of Roswell on Highway 380, elevation 3400 feet, April 19, 1942, *W. H. Long* and *David J. Stouffer* 10082 (1 plant). Dona Ana County: 3 miles west of Mesilla Park on Highway 85, elevation 3850 feet, April 19, 1942, *H. L. Barnett* 10376 (2 plants in Barnett Herbarium, and 2 plants in Long Herbarium); 5 miles from Las Cruces, elevation 3800 feet, October 1, 1939, *W. H. Long* 8434 (2 plants). Arizona. Coconino County: in edge of cinder area, 10 miles east of Flagstaff, elevation 6700 feet, June 16, 1922, *W. H. Long* 9106 (8 plants).

Specimens 9305 and 9354 (type) are deposited in the Herbarium of the University of California at Berkeley; all others, unless otherwise stated, are in the Long Herbarium at Albuquerque.

THE TAXONOMIC POSITION OF POLY- POROLETUS SUBLIVIDUS

ROLF SINGER,¹ WALTER H. SNELL² AND W. LAWRENCE WHITE³

(WITH 4 FIGURES)

In 1934, the second author of this article received from L. R. Hesler a single stipitate sporophore which had certain puzzling features, with a statement that some mycologists to whom it had been submitted could make no satisfactory disposition of it in the Polyporineae, and with the query as to whether or not it could be one of the *Boleti*. The specimen had been collected by A. J. Sharp and J. K. Underwood in pine-oak woods near Allardt, in Fentress County, Tennessee. It was somewhat tough and corky, and had round spores that appeared to be verrucose, and therefore was quite different from anything known in the Boletineae.

In his ignorance of anything of similar nature in the aphyllaphoraceous genera to which it could be referred, Snell (1936) described the specimen as a new species and the type of a new genus of Basidiomycetes, with the generic name suggesting the possible relationship to both the polypores and the boletes. Later (1941), he placed it in a subgroup, Strobilomyceteae. After a study of the original description, and additional data published by Elrod and Blanchard (1939), Singer (1942) concluded that the genus *Polyporoletus* belongs in the Aphyllaphorales rather than in the Boletineae of the Agaricales.

Recently, White examined the specimen and was immediately struck with its resemblance to *Scutiger caeruleoporus* (Peck) Murr., with which he is familiar. A careful anatomical analysis of the type of *Polyporoletus sublividus* and comparison with the available specimens of the *Scutiger caeruleoporus* group, carried

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out by Singer and White, convinced us of the generic identity of *Polyporoletus* and *Scutiger*. Further, it was noted that *S. retipes* (Underwood) Murr. is so similar to *P. sublividus* as to suggest specific identity. Since the spores of the type specimen of *S. retipes*, however, are found to measure $8.5-9 \times 5.3-6.8 \mu$ and to have a simple, thin, entire and smooth wall, they differ from those of *P. sublividus*, as will be noted below.

The reasons for the proposed transfer of *P. sublividus* from the boletes to *Scutiger* are the following:

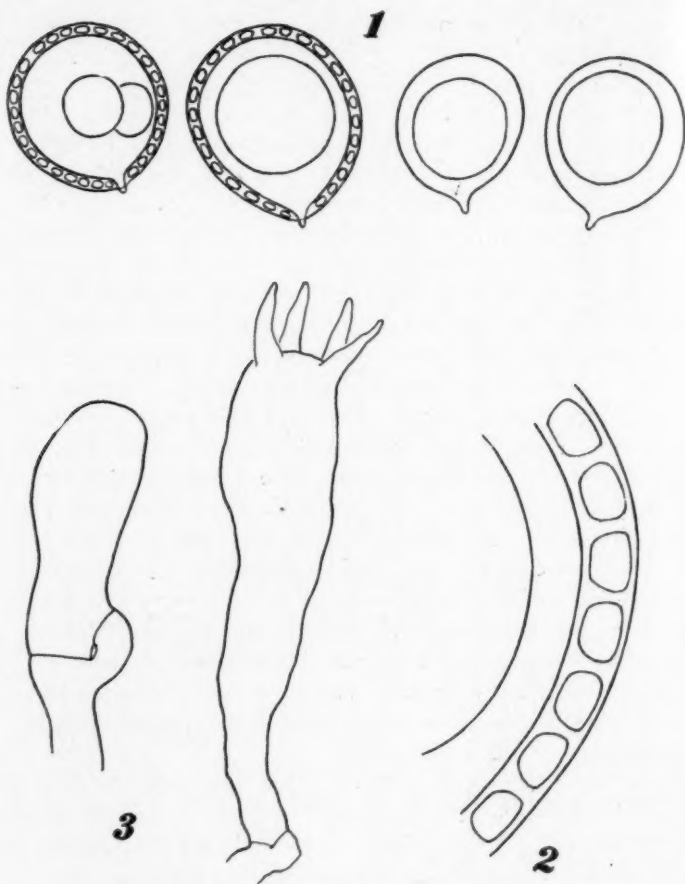
(1) No trace of a bilateral trama in the pore walls of *P. sublividus* is found in sections of the hymenophore. This observation agrees with indications of Elrod and Blanchard.

(2) Numerous clamp connections are present on the septa of the hyphae of *P. sublividus*. This is often the case in *Scutiger*, but never in the Strobilomycetaceae. Only *Gyrodon*, *Paragyrodon*, *Gyroporus* and *Phaeogyroporus*, and some species of *Boletinus* and *Phylloporus* have clamp connections, but in these genera all the other anatomical characters are in disagreement.

(3) The spores of *P. sublividus* are definitely hyaline under the microscope. Hyaline spores are not known in the Strobilomycetaceae and rarely occur in the Boletaceae (genus *Tylopilus*). In this latter genus, the species concerned are of an entirely different type as compared with *Polyporoletus*. A white spore print which *Polyporoletus* would be expected to produce, does not occur in the Boletineae.

(4) There are no cystidia nor cheilocystidia present in *P. sublividus*. The sterile bodies that can be found are best described as cystidioles. This situation does not agree with that known in the Strobilomycetaceae or Boletaceae.

One puzzling problem remains. Snell (l.c.) indicated that the spores of *Polyporoletus sublividus* are verrucose. No rough spored *Scutiger* is known. Reexaminations of the spore-wall of the specimens in question in all kinds of mounting media with a high-power oil-immersion objective by Singer and White did not furnish a clear understanding of the structure of the wall. The spores appeared to be rough because of an incrustation which disappeared more or less completely in alkaline solutions. With this treatment, some of the spores were perfectly smooth and

FIGS. 1-3. *Scutigera sublivida*.

thin-walled, differing from the spores of *Scutigera retipes* only in the measurements ($8-9.5 \times 6.3-7.7 \mu$) while others still appeared indefinitely rough or spinose. Since the spores are non-amyloid, Melzer's reagent did not improve the optical differentiation of the wall.

In previous studies on the anatomy of *Favolaschia*, Singer had used brilliant cresyl-blue as a very satisfactory dye for basidio-

mycetous tissues. When using this dye after a short treatment with KOH in order to dissolve the incrustation, and after having replaced the alkali by water, he obtained a slight violet coloration of the walls. If, for a double-staining effect, the cell-sap is

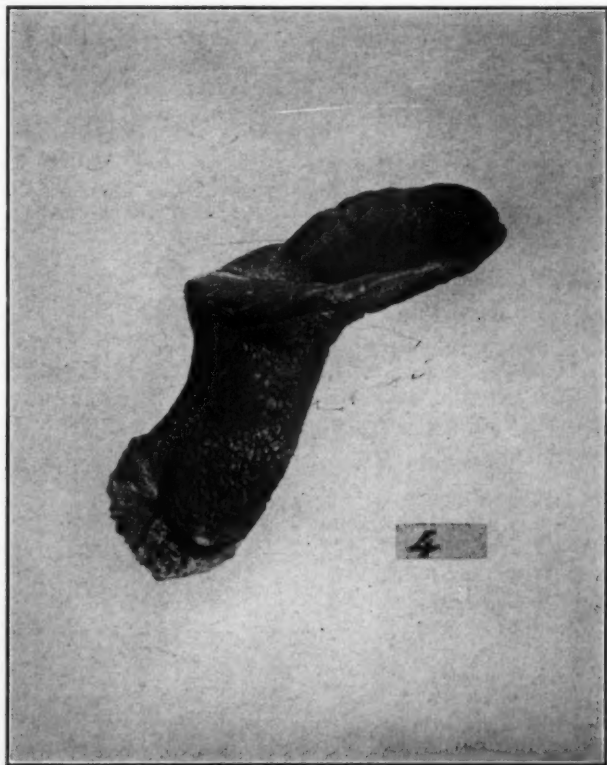


FIG. 4. *Scutigera sublivida*.

colored pinkish-red by phloxine, the structure of the seemingly rough walled spores becomes distinct. It now appears that the spores are not rough at all, but that the wall has a lacunose-cellular structure. There are actually two thin walls between which there are radially connecting walls forming loculi. These loculi included by the two walls and the radial connections have liquid contents. With the double stain, the loculi appear pink

as stained by the phloxine, while the separating walls are stained pale violet by the cresyl-blue. When the upper surface of the spores is focused upon, the loculi appear as lighter shining spots. We did not succeed in proving that there is no connection between the loculi and the part of the spore inside the inner wall; in other words, it is still possible that the inner wall is minutely perforated. On the other hand, the existence of smooth spores with thin and simple or double wall in the same preparation suggests that the inner wall or at least the connecting vertical walls are of a secondary character, formed at full maturity only.

This strange structure is entirely new for basidiomycetous spores, and as far as we know, for fungus spores in general. We propose the term "lacunose spore-wall" for a wall structure of this kind.

The close relationship between *S. retipes* and *P. sublividus* makes it impossible to base a genus *Polyporoletus* on the only character distinguishing the latter from *Scutigera*—i.e. the lacunose spore-wall—inasmuch as spores with normal (simple and homogenous) spore wall, not differing from this of *Scutigera*, are always found in the preparations of *Polyporoletus sublividus*. It would therefore appear that this latter species must be called *Scutigera sublividus* (Snell) Singer, Snell & White, comb. nov.

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1942. Singer, R. Das System der Agaricales. II. *Ann. Myc.* 40: 1-161.

EXPLANATION OF FIGURES

FIGS. 1-4. *Scutigera sublividus* (Snell) Sing., Snell & White: 1, spores, $\times 3000$. Del. W. L. White. 2, part of the spore walls, the line at their left side indicating the position of the central oil drop; greatly enlarged. Del. W. L. White. 3, basidiole and basidium, $\times 540$. Del. W. L. White. 4, dried carpophore in natural size. Phot. Walter H. Snell.

ACTINOPELTE DRYINA

DONALD P. LIMBER¹ AND EDITH K. CASH²

Several collections of a fungus associated with leaf spots of oak and other deciduous trees have recently come to the attention of the writers. These include a leaf spot on *Liquidambar styraciflua* from Monmouth County, N. J.,³ two collections on *Quercus rubra* from Morris Plains, N. J., a collection on *Quercus nigra* from Richmond Hill, Ga., and a specimen on *Eucalyptus* sp. from Avery Island, La. The fungus in each instance appears to be identical with *Leptothyrium dryinum* Sacc., a well-known species distributed in Europe and North America, but apparently hitherto reported only on *Quercus*. Exsiccati specimens and numerous other collections of this species from various sources have been studied and have revealed unreported features of its morphology. From an examination of the literature it is apparent that in none of the published accounts of *L. dryinum* has an accurate and complete description been given of its structure, particularly with reference to the attachment of the fruiting body to the leaf surface of the host.

Leptothyrium dryinum Sacc. was described in 1878 (11, p. 202) as occurring on leaves of *Quercus pedunculata* in northern Italy, the specimen cited having been issued in 1876 as *Mycotheca Veneta* no. 555 under the name of "*? Stigmella dryina* Lév." Other collections of the species have been made in Europe and North America on various species of *Quercus*, and there are numerous references in the literature to its occurrence. Neither

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³ These specimens were taken by inspectors of the U. S. Department of Agriculture Bureau of Entomology and Plant Quarantine in the Special Survey made of the areas in the vicinity of the maritime ports in 1943-1944.

the brief original description nor any other early reference to the species establishes the fact that it differs from the *Leptostromataceae*, as interpreted by modern authors, in that the fructifications are not innate but superficial, and the sporulation inverse, that is, the conidia are borne on the under side of a scutellum, which is attached to the leaf by a central columella. Bubák and Kabát (2, p. 44) commented on the superficial character of the fruiting bodies but gave no detailed account of their structure. The species was redescribed by von Hoehnel in 1925 (8, p. 69) under the name *Actinopelle dryina* (Sacc.) Hoehn. and assigned to his previously established family Actinothyriaceae. Von Hoehnel restricted the application of the name *A. dryina* to European collections of the fungus and erected the new species *A. americana* for the American specimen which he had examined.

The genus *Actinopelle* was established by Saccardo in 1913 (12, p. 315), the type being *A. japonica* Sacc., found on leaves of *Castanea vesca* var. *japonica* from Japan. The fungus was considered by Saccardo to be an ascomycete, and the large subglobose bodies underneath the scutellum were thought to be monosporous asci. Later in the same year Theissen (17, pp. 507-508, f. 6) pointed out that these so-called asci are really conidia and described the manner in which they are borne. His figure shows the radiating strands of the scutellum and the attachment of the conidiophores to its lower surface close to the central columella. Theissen's view was later confirmed by Petrak (10). In both Theissen's description of *A. japonica* and von Hoehnel's account of *A. dryina* and *A. americana* the central columella was erroneously described as composed of small-celled pseudoparenchyma. This interpretation is not borne out by an examination of the available specimens, including exsiccati cited as representing the three species. No such pseudoparenchymatous tissue was seen, the scutellum being in every case connected to mycelium within the host tissues by a large, hyaline, central cell. This type of structure is apparently the same as that noted by Tehon and Stout (16, p. 192, f. 7) in their description of *Leptothyrella Liquidambaris* and in the discussion by Tehon (15) of his proposed family Rhizothyriaceae.

Examination of herbarium specimens and a study of the literature have brought to light additional records of *L. dryinum* on various hosts and under several specific names. It is quite probable that others have been overlooked and may be added to the synonymy later.

Leptothyrium castanicolum Ellis & Ev. was collected by Ellis on *Castanea vesca* in New Jersey and issued as North American Fungi no. 3168 and as Fungi Columbiani no. 782. These specimens have the same data and the material shows evidence of being from a single collection. The label of N. Am. Fungi 3168 bears the note "Very near *L. dryinum* Sacc.," and that of the Fungi Columbiani specimen "Perhaps too near *L. dryinum* Sacc.," indicating that Ellis recognized the close similarity of his species to that of Saccardo. The brief original description gives no spore measurements, but an examination of the exsiccati specimens cited proves that in this, as in other characters, the species on *Castanea* is not specifically distinct from *L. dryinum*.

Two specimens in the Ellis Collection in the New York Botanical Garden, one on apple leaf labeled as *Leptothyrium dryinum* Sacc. f. *Mali* Ellis & Ev., the other on *Sassafras officinale* as *L. dryinum* Sacc. f. *Sassafras*, also proved on examination to be the same as the species on *Quercus*. The forms "mali" and "sassafras" are presumably unpublished herbarium names.

Actinopelte americana Hoehn. is based on an Ellis collection on *Quercus coccinea* from New Jersey issued as Fungi Columbiani no. 286. The description of this species is nearly identical with that of *A. dryina* (Sacc.) Hoehn. in the same article (8). The spores are said to be hyaline and $10-12 \times 6-7 \mu$ in *A. americana*, subhyaline and $12-14 \times 7-8 \mu$ in *A. dryina*. This slight difference in dimensions is no greater than the variation that could reasonably be expected within a species, and the color of the spores also ranges from hyaline to yellowish or pale brown with age and condition of the specimens. In recording the fungus from Iowa, Gilman and Archer (4, p. 306) have therefore reduced *A. americana* to synonymy.

A report of *Actinopelte japonica* Sacc. on several species of *Quercus* (black, chestnut, and red oaks) from New Jersey was

made in 1914 by Schwarze (13). It is most probable that the fungus concerned was *A. dryina* rather than *A. japonica*, since the spore dimensions given ($5-7.7 \times 10-15 \mu$) agree with those in the former, rather than the Japanese species. According to Theissen, the spores of *A. japonica* are $50-60 \times 40-48 \mu$; in the exsiccati specimen examined, Sydow Fungi Exotici exsiccati no. 526 on *Castanea pubinervis* from Japan, they were found to measure $30-48 \times 28-37 \mu$.

Actinopelle japonica has also been listed by Archer (1, p. 361) from West Virginia on *Quercus marilandica*, *Q. prinus*, and *Quercus* sp. The specimens cited (nos. 3207, 3218, and 3350) have been examined and prove to be unquestionably *A. dryina*.

Other possible synonyms of *Actinopelle dryina* include three species described from Illinois: *Leptothyrella* (as "*Leptothyriella*") *Liquidambar* Tehon & Stout (16, p. 192, f. 7) on *Liquidambar styraciflua*, *Pirostoma Nyssae* Tehon (14, p. 137, f. 7-8) on *Nyssa sylvatica*, and *Actinothyrium gloeosporioides* Tehon (14, p. 136, f. 3-6) on *Sassafras variifolium*. Type material of these species has not been examined. The spores of *Pirostoma Nyssae* are said to be olivaceous to brown and slightly verrucose. While brownish spores are frequently found in *A. dryina*, they are, however, smooth, so far as has been observed. Verrucose spores, if the normal condition in *P. Nyssae*, would therefore preclude its being considered synonymous with *A. dryina*. It should be noted that neither *Leptothyrella* nor *Pirostoma* is a valid generic name, as pointed out by Diedicke (3, p. 174) for the former and by von Hoehnel (5) for the latter. Since the spores in *Actinothyrium graminis* G. Kunze, the type of the genus, are acicular, *Actinothyrium gloeosporioides* would seem to be closer to *Actinopelle* than to the genus in which it was described.

Unless some earlier synonym should be discovered, von Hoehnel's name *Actinopelle dryina* appears to be the valid name for the species. Because of the incomplete or erroneous data given in various accounts of this fungus, it seems advisable to give the following emended description, based on examination of recent collections and numerous herbarium specimens.

ACTINOPELTE DRYINA (Sacc.) Hoehn. Mitt. Bot. Inst. Tech. Hochsch. Wien 2: 69. 1925.

Leptothyrium dryinum Sacc. Michelia 2: 202. 1878.

Leptothyrium castanicolum Ellis & Ev. Jour. Myc. 4: 103. 1888.

Actinopelte americana Hoehn. Mitt. Bot. Inst. Tech. Hochsch. Wien 2: 68. 1925.

Actinopelte japonica Auct. Amer., nec Sacc.

Leptothyrium dryinum Sacc. f. *mali* Ellis & Ev. ined. (Ellis Coll. in New York Botanical Garden).

Leptothyrium dryinum Sacc. f. *sassafras* Ellis & Ev. ined. (Ellis Coll. in New York Botanical Garden).

?*Actinothyrium gloeosporioides* Tehon, Mycologia 16: 136. pl. 13, f. 3-6. 1924.

?*Pirostoma Nyssae* Tehon, Mycologia 16: 137. pl. 13, f. 7-8. 1924.

?*Leptothyrella Liquidambaris* Tehon & Stout, Mycologia 21: 192. pl. 13, f. 7. 1929.

Spots small, suborbicular, brownish or reddish brown, margin definite, 2-5 mm. in diam. (the fungus sometimes found on large irregular spots, but then probably as a secondary invader); fructifications superficial, numerous, unevenly scattered, usually epiphyllous, rarely hypophyllous, 60-110 μ in diameter \times 20-40 μ thick, mostly 70-90 \times 20-30 μ ; scutellum membranous, suborbicular, slightly to strongly arched, umbilicate at the center, surface ribbed, central cell hyaline or subhyaline, 7-8 μ in diameter, membrane of yellowish- or greenish-brown, septate, 1-3 bifurcate, hyphal strands radiating to the margin, hyphal ends free as blunt or sharp-pointed spines up to 15 μ long, scutellum borne on a stalk or columella; columella a single cell, subhyaline, oblong with rounded or truncate ends, 10-34 \times 5-9 μ , mostly 17-25 \times 7-8 μ , connected to the mycelium within the leaf by a slender strand at the base; fertile tissue of small, parenchymatous, hyaline to subhyaline cells surrounding the upper part of the columella, arising from the under side of the scutellum near the central cell and bearing the conidiophores which extend downward and outward forming a loose sheath about the columella; conidiophores from short, nearly papillate, up to 12 μ long, straight or curved, swollen at the base, then tapering to a slender neck about 1 μ wide; conidia acrogenous, broad elliptic to subglobose, with rounded ends or the base rarely acute, double

walled, hyaline to pale olivaceous, $10-14 \times 6-9 \mu$, mostly $11-12.5 \times 7-8 \mu$, pushed out from beneath the outer edge of the scutellum when mature.

Hab. in living leaves of *Quercus* spp. and other broadleaved trees in North America and Europe.

Specimens examined:⁴ on *Castanea vesca*, New Jersey, 1894, Ell. & Ev. Am. Fungi 3168 and F. Col. 782, and Mississippi, 1921, E. K. Bynum; *Eucalyptus* sp., Louisiana, 1944, L. A. Mayer 805 (S. S. B. E. P. Q.); *Liquidambar styraciflua*, Maryland, 1913, C. L. Shear (Myc. Coll.), and New Jersey, 1943, E. Kostal 50 (S. S. B. E. P. Q.); *Nyssa sylvatica*, Virginia, 1922, W. W. Diehl; *Pyrus malus*, New Jersey, 1888, J. B. Ellis (N. Y. Bot. Gard.); *Quercus borealis* (?), New York, 1939, Dept. Pl. Path. Cornell Univ. 28869; *Q. coccinea*, New Jersey, 1881, Ell. N. Am. Fungi 732 and F. Col. 286 (Myc. Coll.), Ellis Coll. 2492 (N. Y. Bot. Gard.), and Iowa, 1913, J. P. Anderson; *Q. marilandica*, West Virginia, 1928, W. A. Archer 3207; *Q. nigra*, Georgia, 1943, A. W. Blizzard 809 (S. S. B. E. P. Q.); *Quercus palustris*, Virginia, 1905, G. W. Koiner; *Q. pedunculata*, Type, Italy, Sacc. Myc. Ven. 555; *Q. phellos* (?), South Carolina, 1930, G. A. Meckstroth; *Q. prinus*, West Virginia, W. A. Archer 3212; *Q. pseudorubra*, Italy, Thuem. Myc. Univ. 1584; *Q. rubra*, New Jersey, 1943, M. A. McMaster, Limber 17 (S. S. B. E. P. Q.), and West Virginia, 1896, L. W. Nuttall; *Q. stellata*, Mississippi, 1922, L. E. Miles 752; *Q. velutina*, Wisconsin, 1921, 1925, 1927, 1931, J. J. Davis; *Quercus* sp., Virginia, 1924, J. R. Winston, and 1929, R. W. Davidson 2048-A; West Virginia, 1928, W. A. Archer 3218 and 3350; Kansas, 1922, R. W. Davidson; Texas, 1915, G. L. Fisher; *Sassafras officinale*, New Jersey, 1894, J. B. Ellis (N. Y. Bot. Gard.).

In old, stained, permanent mounts an appearance of septation in the columella can sometimes be observed. Whether this is merely simulation due to unequal staining of the cell contents, or whether a few septa develop with age is not certain. In the

⁴ Unless otherwise stated, specimens cited are in the Mycological Collections, U. S. Bureau of Plant Industry Station, Beltsville, Md. Collections from the Special Survey, Bureau of Entomology and Plant Quarantine, are designated as S. S. B. E. P. Q.

few instances in which this condition has been observed the apparent divisions of the columella were large. The color of the scutellum is quite constant in a given collection but varies from light olivaceous to dark green or greenish brown in different collections, even in the same host genus, as *Quercus*. As the fungus matures under conditions favoring abundant production of conidia, the strands of the scutellum tend to separate, presumably from the pressure of the mass of conidia beneath, so that the texture appears looser, and the scutellum sometimes becomes almost completely disintegrated.

The classification of *Actinopelte* is difficult to determine; its relationship to macroscopically similar genera is uncertain, owing principally to a lack of data on the details of their structure. In his emended description of the genus, Theissen gave no indication as to the family of which he considered it a member. Naoumoff (9, p. 428) suggested including *Actinopelte* with his new genus *Rhizothyrium* in the Pycnothyriaceae. In his System der Fungi Imperfecti (6, pp. 310, 353), von Hoehnel erected the family Actinothyriaceae to include *Actinothyrium* G. Kunze and *Actinopelte* Sacc., adding a third genus, *Columnothyrium* Bubak, to the family two years later (7). The characters by which it may be distinguished from the Pycnothyriaceae are not clearly stated, the presence or absence of a superficial mycelium or subiculum not being mentioned. Although both families are characterized by radiate scutella and inverse sporulation, the Pycnothyriaceae are placed as pycnidial forms near the Leptostromataceae in von Hoehnel's key, while the Actinothyriaceae are classed with the Tuberculariaceae on the basis of being devoid of true pycnidia. A new family, Actinopeltaceae, having the characters of its single genus *Actinopelte*, was proposed a year later by Petrak (10), without reference to von Hoehnel's classification.

More recently the family Rhizothyriaceae has been erected by Tehon (15) to include forms with superficial, radiate fructifications which have inverse sporulation as in the Pycnothyriaceae, but which differ from that family in being devoid of superficial mycelium and in the attachment of the fruiting body, here named "rhizothyrium," by a columella to mycelium within the host

tissue. This family, like Petrak's Actinopeltaceae, does not appear to differ from von Hoehnel's Actinothyriaceae, but is clearly defined. *Rhizothyrium* Naum. and *Actinothyrium* G. Kunze are included by Tehon in the Rhizothyriaceae, but *Actinopelte* is not listed.

A knowledge of the ascus stage of *Actinopelte*, as yet not established, would undoubtedly aid materially in determining the taxonomic position of the genus. Von Hoehnel (7) refers to the Actinothyriaceae as "Nebenfruchtformen, vielleicht von Microthyriaceen"; this does not help to distinguish them from the Pycnothyriaceae, which he had definitely stated to be pycnidial forms of the Microthyriaceae. A possible connection with *Dasyscypha* or *Lachnum* was later suggested by von Hoehnel (8) for *Actinopelte dryina*, but no evidence is given for this assumption. According to Tehon (15) the morphology of the Rhizothyriaceae suggests that they may be pycnidial forms of the Polystomellaceae.

It is obvious that further data obtained from a more detailed study of these fungi will be necessary before any satisfactory classification can be attempted. On the basis of present knowledge, Tehon's grouping of the Rhizothyriaceae (= Actinothyriaceae Hoehn.) with the Pycnothyriaceae in a proposed order named the Pycnothyriales appears more logical than von Hoehnel's classification, in recognizing both the differences between these two families and the common characters that distinguish them from the Leptostromataceae.

The writers are indebted to Dr. F. J. Seaver of the New York Botanical Garden and Dr. D. H. Linder of the Farlow Herbarium for the privilege of examining herbarium specimens in connection with this study.

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FABRIC DETERIORATION BY THIRTEEN DESCRIBED AND THREE NEW SPECIES OF CHAETOMIUM¹

GLENN A. GREATHOUSE² AND L. M. AMES³

(WITH 7 FIGURES)

The rapid deterioration of military fabrics in many tropical and subtropical areas has focused attention on cellulose decomposing microorganisms, prominent among them being species of the genus *Chaetomium*. Species of *Chaetomium* have been listed among the cellulose destroyers for many years; however, the information being largely observational (26, 14, 27). Few studies have been carried out to determine the importance of species other than *C. globosum* Kunze in the deterioration of cellulose materials. Frequently other species of *Chaetomium*, such as *C. elatum*, *C. funiculum* have been isolated from cotton fabrics. Approximately one-half of the known species of *Chaetomium* are included in this study.

In many early studies on deterioration of cellulose by microorganisms, true distinction was not made between decomposition of cellulose and other carbohydrates. In other words, if an organism was observed to grow on wood or stubble, it was classified as a cellulose decomposer. Such organisms may utilize carbon sources other than cellulose. Greathouse, Klemme, and Barker (15) developed a method that offers advantages in evaluating the ability of microorganisms to digest high-polymer cellulose. The evidence included in the present paper establishes more certainly the ability of sixteen species of *Chaetomium* to decompose cotton fabric under varied conditions through the use

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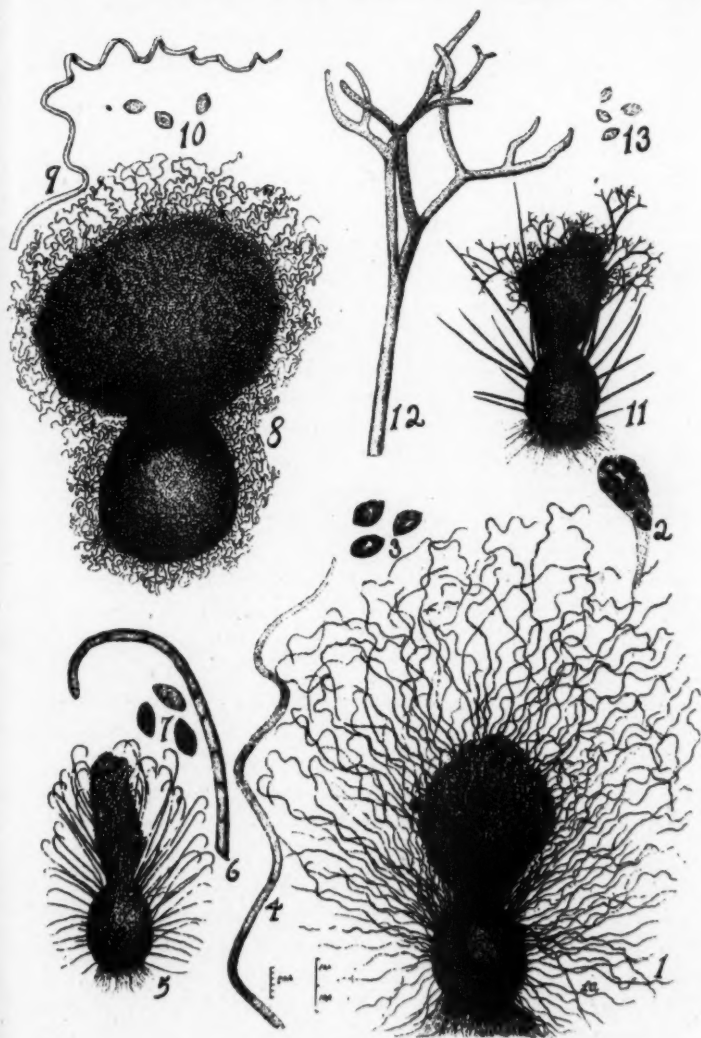


FIG. 1. 1-4, *Chaetomium globosum* Kunze; 1, mature perithecium; 2, ascus containing ascospores; 3, mature ascospores; 4, terminal hair; 5-7, *Chaetomium aureum* Chivers; 5, mature perithecium; 6, terminal hair; 7, mature ascospores; 8-10, *Chaetomium ochraceum* Tschudy; 8, mature perithecium; 9, terminal hair; 10, mature ascospores; 11-13, *Chaetomium funicolum* Cooke; 11, mature perithecium; 12, terminal hair; 13, mature ascospores.

of this method. Drawings of the *Chaetomium* species are included to aid readers to visualize the organisms herein described.

LITERATURE REVIEW

In 1817 Kunze (17) published a description of a hitherto unrecognized genus giving to it the name *Chaetomium* and described the first species under the name *C. globosum*. One year later he published a description of a second species which he called *C. elatum* (18). Corda (7, 8, 9) amended the original description given by Kunze and described two new species that are still accepted, *C. indicum* and *C. murorum*. Fuckel (12) and Cooke (6) also made valuable contributions in their descriptions of two new species under the names *C. crispatum* and *C. funiculum*.

Zopf (30) described as new *C. spirale* and described or re-described *C. cuniculorum* and *C. bostrychodes*. *C. contortum* was described by Peck (24) in 1896 and *C. simile* by Massee and Salmon (21) in 1902. Palliser (23) described for the first time *C. aterrimum* under a name given it by Ellis and Everhart (11). She also described the species *C. cochliodes*, *C. spirochaete*, and *C. flexuosum* as new. Tschudy (29) described two new species, *C. ochraceum* and *C. cancroideum*, which were isolated from decomposing reeds.

Bainier (2) published a monograph of the genus *Chaetomium* in the year 1910. He gave a brief historical sketch and a review of the genus. In addition, Bainier described 22 species and 3 varieties, 12 species and 2 varieties of which are described under new names; in this work the synonymy of the genus was increased.

In 1910 Palliser published a revision of the *Chaetomiaceae* in the North American Flora, where 17 species are enumerated including descriptions on three species previously unknown.

Chivers (10) gives the characteristics of the genus *Chaetomium* and a key to 28 species in an outstanding monograph.

Unidentified *Chaetomia* have been isolated from cotton fabrics under many different conditions and locations (4, 5, 14, 19, 22, 26). In 1934 *Chaetomium globosum* was selected by Thom et al (27) as a suitable test organism for evaluating the mildew resistance of outdoor cotton fabrics. This fungus has since been employed in many Government and Commercial laboratories in

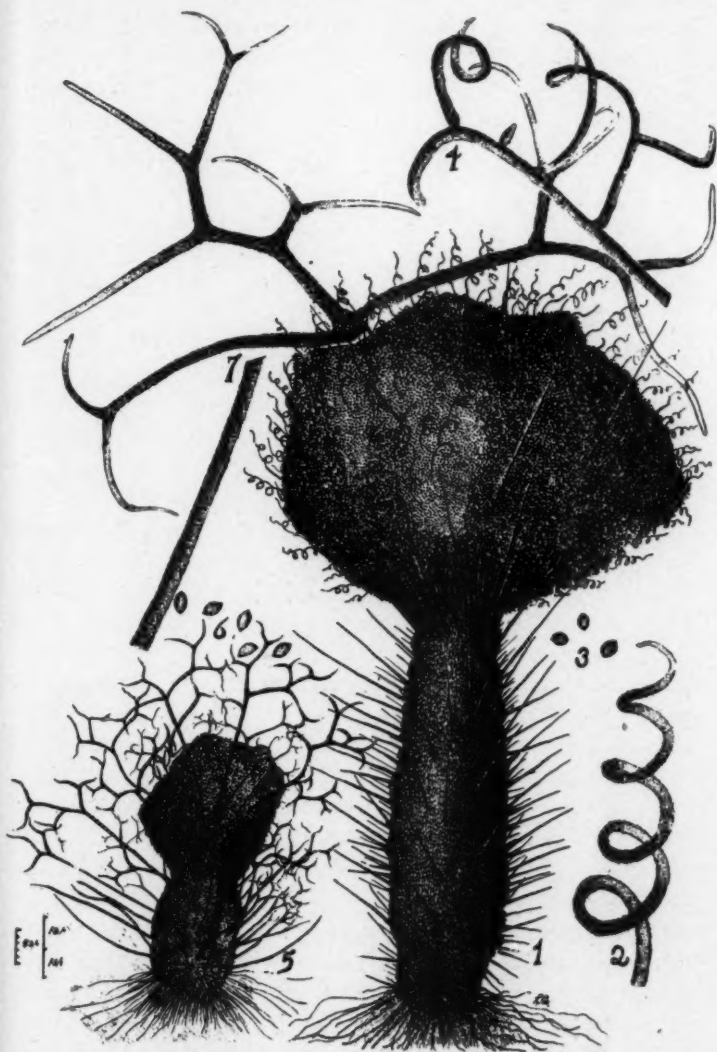


FIG. 2. 1-3, *Chaetomium caprinum* Bainier; 1, mature perithecium; 2, 4, terminal hairs; 3, mature ascospores; 5-7, *Chaetomium elatum* Kunze & Schmidt; 5, mature perithecium; 6, mature ascospores; 7, terminal hair.

connection with the evaluation of mildew-preventives applied to fabrics (3, 13, 15, 16, 20, 25). Thom et al (27) states: "It has thus been shown that *Chaetomium* is a common cause of destruction of awnings, paulins, bags, shock covers, and tentage in the field."

MATERIAL AND METHODS

Bleached, 8-ounce Army duck, with an original breaking strength of 140.5 lbs., was used throughout these investigations. Before exposure to the attack of fungi, the fabric was treated to remove sizing finishes, any residual waxes, pectins, and other substances that might serve as added nutrients. For the degreasing procedure the fabric was extracted twice for 2 hours each in two changes of carbon tetrachloride, followed by a treatment with 0.05 per cent starch and protein-solubilizing enzyme and thoroughly rinsed in distilled water (1).

The fabric was divided into large blocks so that each block would furnish one of the ten replicates used for each determination. The blocks were cut into strips measuring 15 cm. (6 inches) in the warp direction by 3.1 cm. (1.25 inches) and by raveling the width was reduced to exactly 2.5 cm. (1 inch) (1).

The "glass-wick" procedure and the nutrient medium designated as Formula A⁴ described by Greathouse, Klemme and Barker (15) was used. The inoculated strips of fabric were incubated for a 7-day period in a darkened, air conditioned room which was maintained at 85° to 86° F. (29.4 to 30° C.) and 90 to 94 per cent relative humidity. Other experiments have shown that this is approximately the optimum temperature for *C. globosum* to yield the greatest loss in breaking strength of cotton fabric. All results are based on the average change of tensile strength of ten strips subjected to individual isolates.

The final strength of the test fabric after incubation with the fungus was recorded in pounds and calculated as the percentage of the original breaking strength.

The pH values of the media were determined with the aid of the Beckman glass-electrode apparatus.

⁴ K₂HPO₄ 1.3940 g., MgSO₄·7H₂O 0.7395 g., NH₄NO₃ 1.0006 g., Fe, Zn and Mn 0.001 g. per liter distilled water.

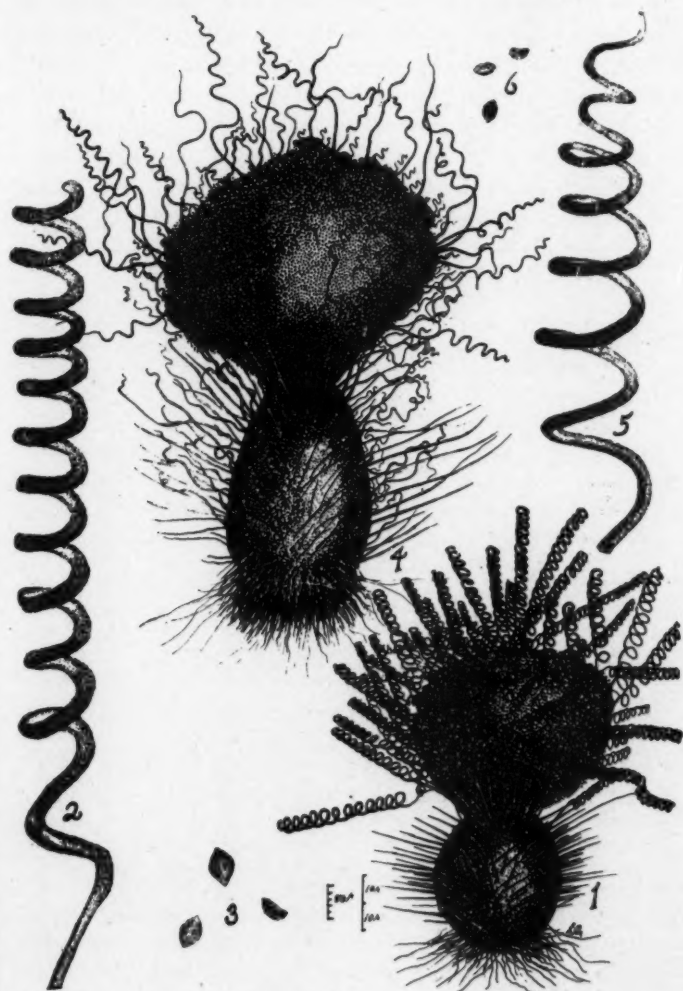


FIG. 3. 1-3, *Chaetomium atterimum* Ellis & Ev.; 1, mature perithecial; 2, terminal hair; 3, mature ascospores; 4-6, *Chaetomium cochliodes* Palliser; 4, mature perithecial; 5, terminal hair; 6, mature ascospores.

Four isolates of *C. globosum* Kunze, two isolates each of *C. funiculum* Cooke, *C. elatum* Kunze & Schmidt, and *C. cochliodes* Palliser, and one isolate each of *C. caprinum* Bainier, *C. ochraceum* Tschudy, and a second species described as *C. cancroideum* Tschudy, which morphologically resembles *C. funiculum*, *C. aterrimum* Ellis & Ev., *C. aureum* Chivers, *C. murorum* Corda, *C. contortum* Peck, *C. bostrychodes* Zopf, *C. convolutum* Chivers, *C. dolichotrichum* Ames, *C. microcephalum* Ames, *C. pachypo-*

TABLE I
THE SOURCE AND IDENTIFICATION OF CHAETOMIUM ISOLATES USED IN
THIS INVESTIGATION

Species	Isolate number	Source and location of isolate	Identified by:
<i>C. globosum</i> **	1042.4	Collection of Chas. Thom	A. H. Chivers
<i>C. globosum</i>	1042.5	G. W. Martin—1410, Barre Colorado Isl., Aug. 1937	L. M. Ames
<i>C. globosum</i>	1042.6	G. W. Martin—4312, Panama, Prov. Chiriquie, alt. 2000 m., Aug. 1937	L. M. Ames
<i>C. globosum</i>	1042.7	Mycologists—Australia	L. M. Ames
<i>C. caprinum</i>	1043.0	L. M. Ames from New England	L. M. Ames
<i>C. cancroideum</i>	1044.4	Tschudy—decomposing reeds, State of Washington	R. H. Tschudy
<i>C. funiculum</i>	1043.1	Warehouse cotton—K. Bollenbacher	L. M. Ames
<i>C. funiculum</i>	1043.2	L. M. Ames—from the Great Smoky Mts. of Tennessee	L. M. Ames
<i>C. elatum</i>	1043.4	H. Humfeld—storage cotton	L. M. Ames
<i>C. elatum</i>	1043.5	K. Bollenbacher—Mattress cotton	L. M. Ames
<i>C. cochliodes</i>	1043.6	G. W. Martin—3855, B. Columbia, Sierra Nevada de Santa Marta, alt. 1250 m., August 1935	L. M. Ames
<i>C. cochliodes</i>	1043.7	G. W. Martin—4558, Panama Canal Zone, Summit, August 1937	L. M. Ames
<i>C. ochraceum</i>	1044.5	Tschudy, decomposing reeds, State of Washington	R. H. Tschudy
<i>C. aterrimum</i>	1043.8	L. M. Ames from the Gr. Smoky Mts.	L. M. Ames
<i>C. aureum</i>	1043.9	L. M. Ames from the Gr. Smoky Mts.	L. M. Ames
<i>C. pachypodioides</i>	1044.3	L. M. Ames from the Gr. Smoky Mts.	L. M. Ames
<i>C. convolutum</i>	1044.0	L. M. Ames from the Gr. Smoky Mts.	L. M. Ames
<i>C. murorum</i>	1044.8	L. M. Ames from the Gr. Smoky Mts.	L. M. Ames
<i>C. contortum</i>	1044.9	L. M. Ames from the Gr. Smoky Mts.	L. M. Ames
<i>C. microcephalum</i>	1045.0	L. M. Ames from the Gr. Smoky Mts.	L. M. Ames
<i>C. dolichotrichum</i>	1044.7	L. M. Ames from the Gr. Smoky Mts.	L. M. Ames
<i>C. bostrychodes</i>	1045.1	L. M. Ames from the Gr. Smoky Mts.	L. M. Ames

dioides Ames, were used in this investigation. These fungi were cultured on the cotton fabric in contact with the mineral salts medium described as Formula A and on three subsequent media modified only by the substitution of equivalent amounts of nitrogen in the form of NaNO_3 , $(\text{NH}_4)_2\text{SO}_4$, and $\text{NH}_4\text{H}_2\text{PO}_4$. The nitrogen content of these media is 0.350 gram per liter. The original pH values of these media were 7.1, 6.6, 5.8, and 5.5 respectively. After the growth of *Chaetomium* species the pH range was 6.7–8.4, 5.8–6.6, 4.6–5.8, and 4.3–5.5, respectively.

The source and identification of the *Chaetomium* species used in this investigation are recorded in table I. It will be noted that one of the isolates of *Chaetomium globosum* taken for this study is the fungus employed by the Australian mycologists as a test organism for the evaluation of war service materials. Two other isolates for *C. globosum* and of *C. cochliodes* were secured from the Panama Canal area.

During the course of this investigation three new species of *Chaetomium* were used in the experimental work; their descriptions are given at this time accompanied with illustrations.

Type specimens have been deposited at the Farlow Herbarium, Cambridge, Massachusetts, subcultures have been deposited at the New York Botanical Garden, Bronx Park, New York, as well as in the Mycological Herbarium of the U. S. Department of Agriculture located at the Plant Industry Station, Beltsville, Maryland.

***Chaetomium dolichotrichum* Ames, sp. nov. (FIG. 5: 8-10)**

Perithecio nigro, parvo, globoso vel ovato-globoso 80×85 ($50-90 \times 52-95$), cum substrato laxius connato. Pilis lateralibus haud numerosis, laevibus, flexuosis. Pilis terminalibus dimorphicis, quorum majoribus in capitulo denso aggregatis, dichotome ramosis, ramis late patentibus, sub angulo acuto divergentibus, basi nigris ca. 6.5μ crassis, in apicem gracilem terminantibus; minoribus terminalibus, paucioribus, gracilibus, nigris, apicem sporiferum longius excurrentibus, interdum ramosis, ca. $2-2.5 \mu$ diametro.

Type locality, Cades Cove, the Great Smoky Mts., Tenn.

***Chaetomium microcephalum* Ames, sp. nov. (FIG. 6: 4-7)**

Perithecio albido vel griseo, alto, gracili $250 \times 120 \mu$ ($200-400 \times 80-140$) cum substrato laxius connato. Sporibus exudatis ad apicem peritheci capitulatis congregatis. Pilis lateralibus numerosis, apice collapsilibus, manifeste septatis. Pilis terminalibus crassioribus simplicibus vel ramosis, septatis. Pilis ramosis basi latis $7.5-8.5 \mu$ subinde in apicem gracilem acutatis, undulatis spiralibusve, circumvolutionibus 2-4. Sporibus maturis pallidis, brunneo-olivaceis, ovalibus, utrinque apiculatis vel uno apice rotundatis.

Type locality: Cades Cove, The Great Smoky Mts., Tenn.

***Chaetomium pachypodioides* Ames, sp. nov. (FIG. 7: 1-3)**

Perithecio nigro, magno, alto, elongato, basi saepissime crassiore, ad apicem angustato $350 \times 150 \mu$ ($250-475 \times 120-200$) in subiculo insidenti e rhizoides atre brunneo-olivaceis vel nigris efformato, apicibus sporiferis interdum breviter cirrhis. Pilis lateralibus sat numerosis, acanthoideis, acuminatis,

septatis. Pilis terminalibus apicem sporiferum valde excedentibus, numerosis, acuminatis, undulatis spiralibusve, septatis, minute granulosis, basi ca. $6\ \mu$ crassis, in apicem ecoloratum terminatis. Ascosporis maturis pallidis brunneo-olivaceis, formam *Citri Lemoni* mentientibus, utrinque apiculatis.

Type locality, Cades Cove, The Great Smoky Mts., Tenn.

EXPERIMENTAL RESULTS

Comparisons of the influence on breaking strength of these sixteen species of *Chaetomium* as grown on the media described is summarized in table II.

TABLE II
EFFECT OF DIFFERENT SPECIES OF CHAETOMIUM, GROWN ON FOUR
NITROGEN SOURCES, ON THE BREAKING STRENGTH OF
8-OUNCE COTTON DUCK, AFTER 7 DAYS' INCUBATION

Species	Isolate number	Residual breaking strength as per cent of the original				Physiological groups
		NaNO ₂	NH ₄ NO ₃	(NH ₄) ₂ SO ₄	NH ₄ H ₂ PO ₄	
<i>C. globosum</i>	1042.4	7.6	13.9	21.2	24.1	I
<i>C. globosum</i>	1042.5	9.1	11.4	20.2	28.8	I
<i>C. globosum</i>	1042.6	18.6	11.6	23.3	27.4	I
<i>C. globosum</i>	1042.7	18.6	19.1	20.0	25.2	I
<i>C. caprinum</i>	1043.0	10.8	10.1	15.8	33.6	I
<i>C. cancroideum</i>	1044.4	25.2	10.6	26.0	21.4	II
<i>C. dolichotrichum</i> ..	1044.7	37.0	19.6	20.9	20.0	III
<i>C. funiculum</i>	1043.1	49.7	21.9	20.9	18.0	III
<i>C. funiculum</i>	1043.2	48.2	15.3	19.9	13.6	III
<i>C. elatum</i>	1043.4	45.0	28.6	28.5	32.9	III
<i>C. elatum</i>	1043.5	47.9	22.6	19.6	34.5	III
<i>C. contortum</i>	1044.9	34.8	25.2	28.7	27.5	III
<i>C. bostrychodes</i> ...	1045.1	22.9	20.2	23.9	23.9	IV
<i>C. cochliodes</i>	1043.6	44.3	51.3	54.7	55.0	IV
<i>C. cochliodes</i>	1043.7	54.9	43.4	48.0	61.9	IV
<i>C. murorum</i>	1044.8	43.7	45.2	46.7	48.9	IV
<i>C. ochraceum</i>	1044.5	44.4	54.1	54.4	55.6	IV
<i>C. atterimum</i>	1043.8	50.9	45.9	44.5	45.3	IV
<i>C. aureum</i>	1043.9	50.5	45.5	60.6	62.1	IV
<i>C. pachypodioides</i> ..	1044.3	74.9	70.3	38.4	33.1	V
<i>C. convolutum</i>	1044.0	89.6	87.9	89.9	82.7	VI
<i>C. microcephalum</i> ..	1045.0	91.3	54.0	100.0	100.0	VII
pH of original autoclaved medium:		7.1	6.6	5.8	5.5	
pH of medium at harvest.....		6.7-8.4	5.8-6.6	4.6-5.8	4.3-5.5	

The results presented in table II show that the *Chaetomium* species vary in their ability to decompose cellulose and in their reaction to different nitrogen sources. It is observed that there is variation between several isolates of some species; further

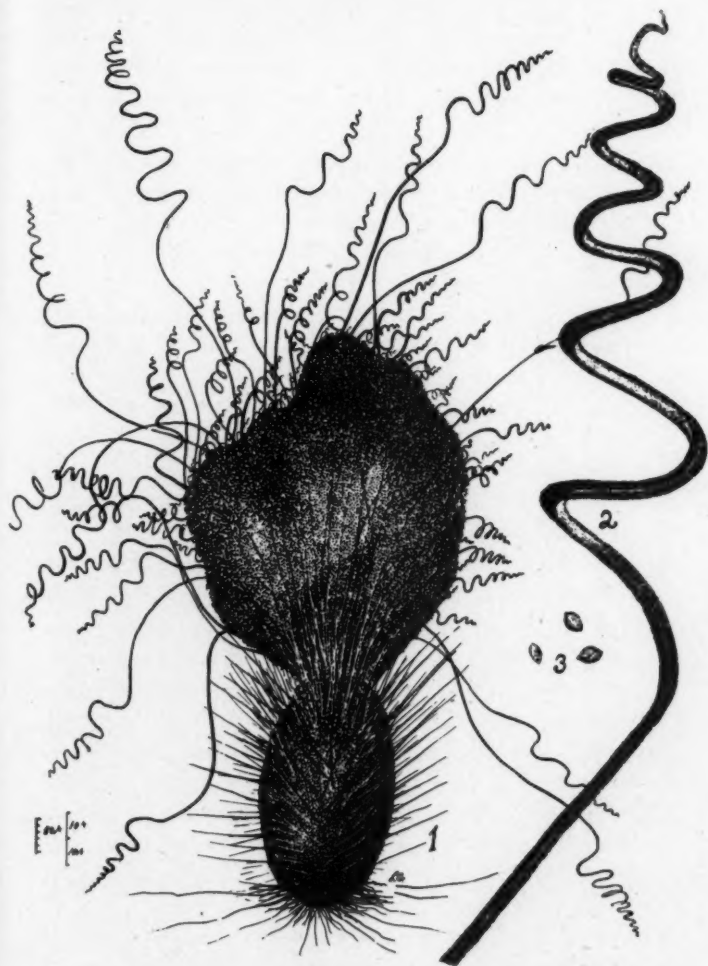


FIG. 4. *Chaetomium convolutum* Chivers; 1, mature perithecium; 2, terminal hair; 3, mature ascospores.

studies of such variation may be of interest. On the basis of results obtained an arbitrary classification into physiological groups has been made for convenience of discussion. Information on the following groups is based upon the conditions of our tests, *i.e.*, using 4 nitrogen sources and an incubation period of 7 days.

Group I includes *C. globosum* and *C. caprinum* which are very active cellulose decomposers that produce slightly greater losses in breaking strength on a nitrogen source, NaNO_3 , that ranges on the alkaline side of neutrality following the utilization of the NO_3 radical by the fungus.

Group II is represented by *C. cancroideum*, morphologically similar to *C. funiculum*, which is an active cellulose decomposer that seems to be most active on a neutral to slightly acid medium, NH_4NO_3 .

Group III contains *C. dolichotrichum*, *C. funiculum*, *C. elatum*, and *C. contortum* which are active cellulose destroyers that thrive especially well on the more acid nitrogen sources, NH_4NO_3 , $(\text{NH}_4)_2\text{SO}_4$, and $\text{NH}_4\text{H}_2\text{PO}_4$.

Group IV is characterized by species that are active to moderately active in destroying cellulose and that have no marked preference for nitrogen sources.

Group V is restricted in its preference of nitrogen source to $(\text{NH}_4)_2\text{SO}_4$ and $\text{NH}_4\text{H}_2\text{PO}_4$ on which it produces moderate losses in breaking strength of the cotton fabric.

Group VI represented by *C. convolutum* is a relatively inactive cellulose decomposer.

Group VII is represented by *C. microcephalum*. It seems to be restricted in its ability to decompose cellulose under these experimental conditions to a very narrow limit, *i.e.* NH_4NO_3 medium.

Several other isolates of *Chaetomium* were studied and found to be inactive as cellulose decomposers. Among these were two species received under the name *C. trigonosporum* and *C. caninum* received from J. D. Machacek, Dominion Laboratory of Plant Pathology, Winnipeg, Man. These species failed to grow on any mineral salts-cellulose media tested. Slight differences in the

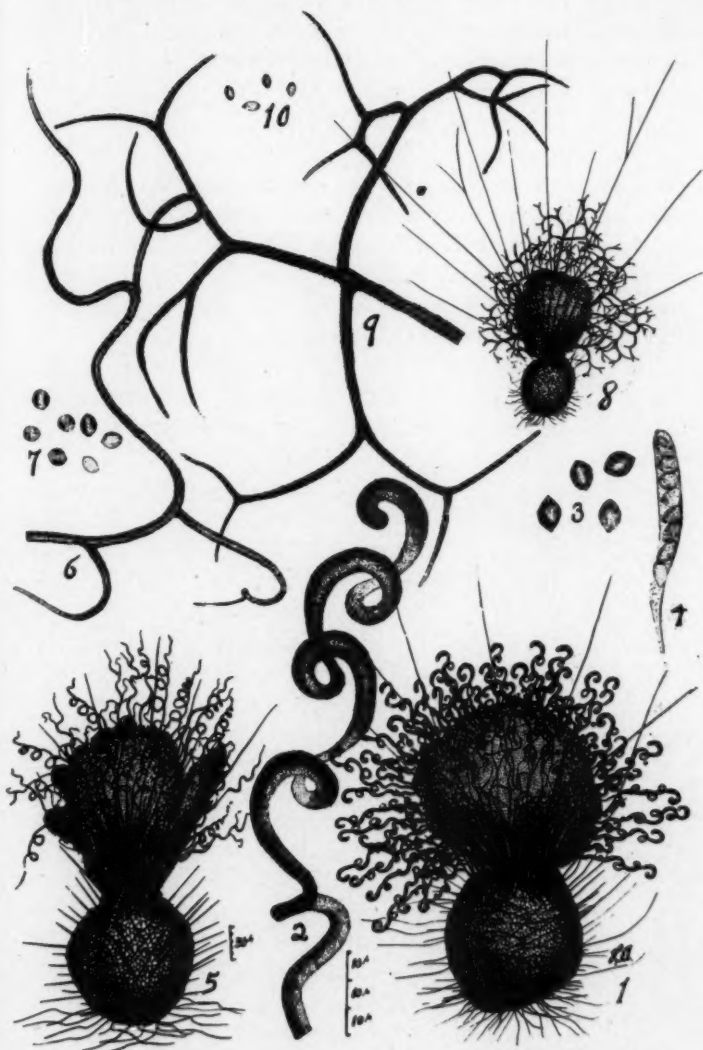


FIG. 5. 1-4, *Chaetomium contortum* Peck; 1, mature perithecial head; 2, terminal hair; 3, mature ascospores; 4, ascus containing immature ascospores; 5-7, *Chaetomium bostrychodes* Zopf; 5, mature perithecial head; 6, terminal hair; 7, mature ascospores; 8-10, *Chaetomium dolichotrichum* Ames; 8, mature perithecial head; 9, terminal hair; 10, mature ascospores.

ability of different isolates of the same species of *Chaetomium* to deteriorate cellulose may be observed from data presented in table II.

DISCUSSION

The impact of war has brought to a focus the necessity of learning the characteristics of the causal agents in the decomposition of cotton fabrics and necessitates the determination of means of preventing fabric destruction. The study here presented is a beginning in this direction and is chiefly concerned with the study of the ability of various species of *Chaetomium* in decomposing cotton duck within a specified period of time.

Thom et al. (28) secured quantitative data that represent the ability of several *Chaetomium* species to destroy cellulose. In addition to *C. globosum* they tested *C. cochliodes*, *C. funiculum*, and *C. aureum* on one nutrient medium which is similar to the one used in this investigation when NaNO_3 is used as the nitrogen source. They found that *C. globosum*, *C. cochliodes*, *C. funiculum*, and *C. aureum* produced 94.5, 91.6, 89.7, and 88.0 per cent loss in breaking strength of 8-ounce cotton duck after 14 days incubation, respectively. In the present investigation, the same species of *Chaetomium* when grown on the NaNO_3 medium, Table II, produced 92.4, 50.4, 49.1, and 49.5 per cent less in breaking strength after 7 days incubation period. Culture transfers from the same *C. globosum* isolate used by Thom et al were used in this study and thus may account for the close similarity in results for this species. The cause of the differences obtained between the two investigations with the other three species is not known. It may be due to intra specific variations.

The loss in breaking strength of cotton duck resulting from the growth of *C. globosum* and *C. elatum* on NaNO_3 , NH_4NO_3 and $\text{NH}_4\text{H}_2\text{PO}_4$ as the nitrogen source media was reported by Greathouse et al (15). These investigators found that *C. globosum* gave a loss in fabric breaking strength of 118 pounds with NaNO_3 , 108 pounds with NH_4NO_3 and 96 pounds with $\text{NH}_4\text{H}_2\text{PO}_4$ as nitrogen sources. On the other hand, the growth of *C. elatum* under similar conditions resulted in losses of 67, 89, and 88 pounds, respectively. The results with these two species show that the nitrogen source is an important factor in determining

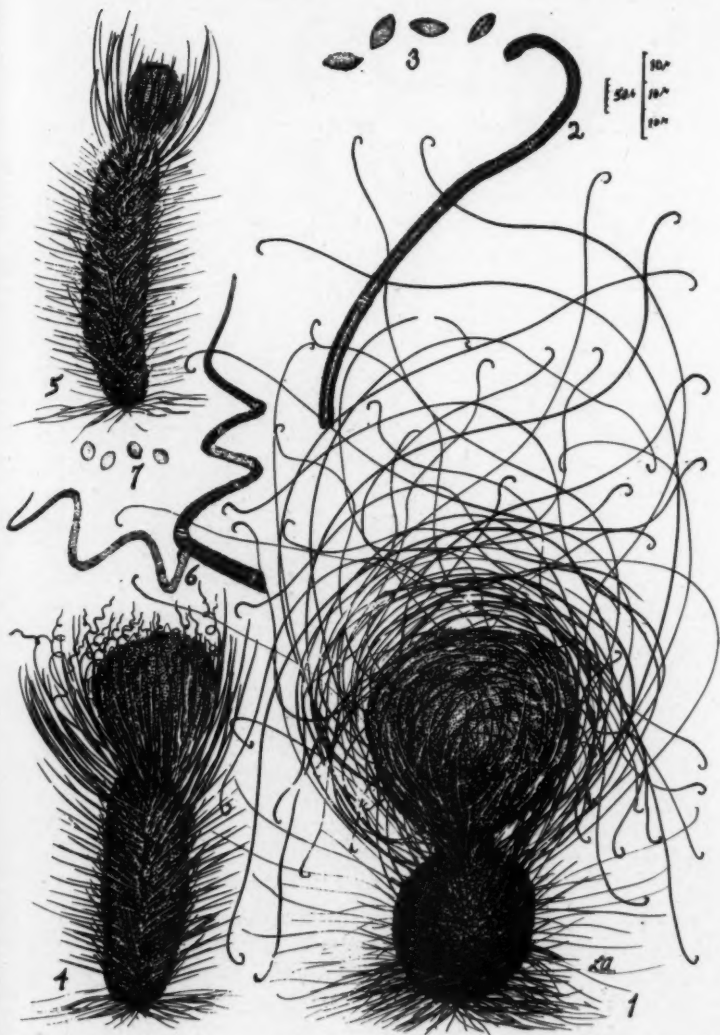


FIG. 6. 1-3, *Chaetomium murorum* Corda; 1, mature perithecia; 2, terminal hair; 3, mature ascospores; 4-7, *Chaetomium microcephalum* Ames; 4-5, mature perithecia; 6, terminal hair; 7, mature ascospores.

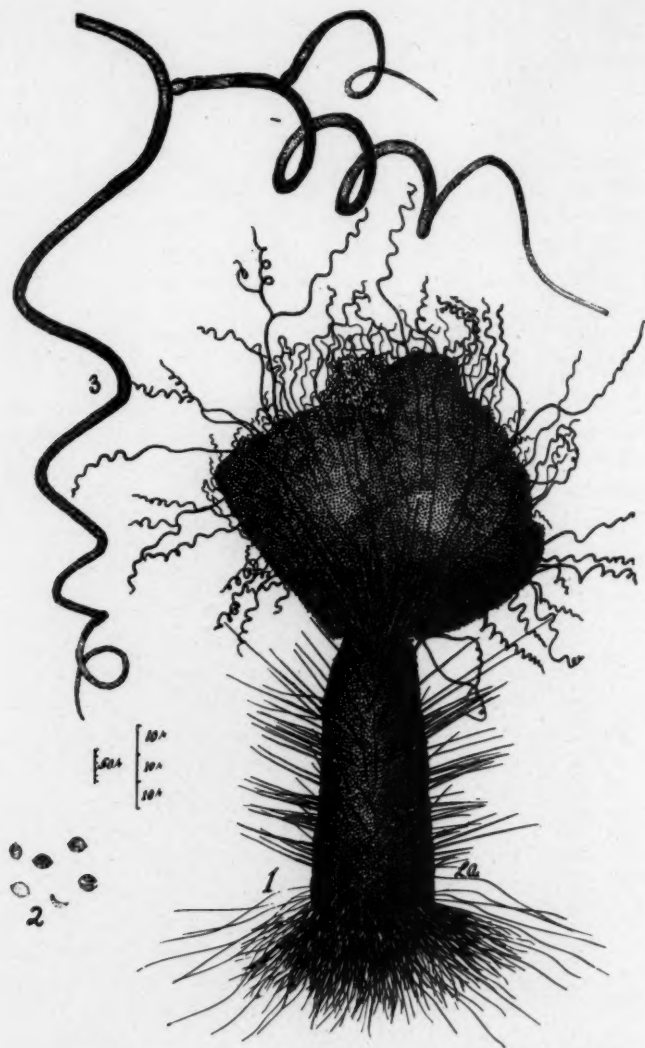


FIG. 7. *Chaetomium pachypodioides* Ames; 1, mature perithecium; 2, mature ascospores; 3, terminal hair.

the response of cellulose-decomposing fungi. This phenomenon is even more strikingly demonstrated from the data presented in table II where a comparison of sixteen different *Chaetomium* species was made. Most *Chaetomium* species, like fungi in general, grow best on media neutral or slightly acid in reaction.

C. globosum, the fungus chosen as the test organism by Thom et al (28), is characteristic of the genus *Chaetomium* in decomposing cellulose, with the possible exception that it thrives best in a slightly alkaline medium, which is the exception rather than the general rule among *Chaetomium* species as well as fungi in general. The organism to be used in testing fabrics for mildew resistance should be capable of rapid destruction; it should be stable in its cultural and cellulose destroying characteristics; its response to specific factors, i.e. pH, temperature, fabric preservative, etc., should have been established; and its distribution and occurrence in nature should be known. *C. globosum*, as well as several of the other *Chaetomium* species, meet the majority of these requirements.

SUMMARY

1. Sixteen species of *Chaetomium* have been tested to determine their ability to decompose cotton fabric. Enumerated in a descending order according to their deteriorating ability they are: *C. globosum*, *C. caprinum*, *C. cancroideum*, *C. dolichotrichum*, *C. funiculum*, *C. elatum*, *C. contortum*, *C. bostrychodes*, *C. cochliodes*, *C. murorum*, *C. ochraceum*, *C. aterrimum*, *C. aureum*, *C. pachypodioides*, *C. convolutum*, *C. microcephalum*.

2. Three new species of *Chaetomium* have been described, *C. dolichotrichum* Ames, *C. pachypodioides* Ames, and *C. microcephalum* Ames.

3. The ability of the sixteen species of *Chaetomium* to decompose cellulose fabric in the presence of a standard nutrient salt medium in which the source of nitrogen was obtained from four different sources (NaNO_3 , NH_4NO_3 , $(\text{NH}_4)_2\text{SO}_4$, and $\text{NH}_4\text{H}_2\text{PO}_4$) were studied. It was found that the sixteen species studied fall into seven groups based upon their ability to utilize the cotton fabric in the presence of different nitrogen sources. The percentage of loss in breaking strength of the fabric following a

seven day incubation of each isolate was the criteria used for physiological differentiation between species.

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EXPLANATION OF FIGURES

All figures have been outlined by the aid of a camera lucida. The perithecia are all drawn to the same scale under low power, a scale being included on each plate. The detailed drawings of terminal hairs and spores were drawn under the high power objective and a scale in microns is included on each plate so that direct measurements can be made.

NOTES AND BRIEF ARTICLES

HYDNUM FLORIFORME IN FLORIDA

This beautiful species was collected by the author under laurel oaks in Gainesville during the summer of 1944. Originally described from Bavaria by Schaeffer, it had been found in dry woods from New England southward to Alabama. *H. aurantiacum* Alb. & Schw. is not distinct. Although assigned to both *Hydnellum* and *Calodon*, it properly belongs in the latter. Miller says the two genera are not sufficiently distinct anyway. I sent a specimen to Dr. Coker, who kindly verified my determination.—W. A. MURRILL.

GIANT PUFFBALL IN MAINE

Worthy of note are the following data on a specimen of Giant Puffball (*Calvatia gigantea* Batsch.) collected in Brewer, Maine, on August 27, 1943, by Mr. A. L. Hodgkins. The specimen had a girth of 46 inches, diameter of approximately 14.5 inches, height of 9 inches, and weight of 7.5 pounds at the time of collection. After air-drying in a warm room for nearly a year the weight dropped to .5 pound. Although much larger puffballs have been recorded,¹ those of the size noted above are certainly rarely met with in this vicinity.—F. HYLAND.

Announcement is made of the publication of a lithoprint edition of the 'classical Sylloge Fungorum of Saccardo, under license from the alien property custodian. The work is issued in twenty-five (25) volumes bound in twenty-seven as originally published. In the interests of economy both from the standpoint of paper and printing costs the printing surface of the volumes has been reduced seven per cent. This, however, does not appreciably affect the readability of the text. The paper used was especially selected for the purpose and was tested by the United States

¹ The weight of the Ottawa specimen is recorded as 18.75 pounds. (See Mushrooms and Toadstools by H. T. Güssow and W. S. Odell. Ottawa, 1927.)

National Bureau of Standards. The volumes are bound in library buckram.

Further information may be secured from the firm of Edwards Bros., Inc., Ann Arbor, Michigan.

A NEW POLYPORE FROM UTAH

The species described below was sent to me by Dr. Rhoads. It is tomentose like *P. maculosus* Murr. but resembles *P. elegans* Fries in spore characters.

Polyporus submaculosus sp. nov.

Pileo 3 cm. lato, tomentoso, fumoso, badio-maculato; tubulis 1 mm. longis, poris 4 per mm., angulatis, albis, demum isabellinis; sporis oblongis, $10 \times 3 \mu$; stipite excentrico, nigro, 1×0.5 cm.

Pileus subcircular, slightly depressed, solitary, $3 \times 3 \times 0.5$ cm.; surface covered with thin fumose tomentum except near the undulate entire margin, where there are small glabrous bay spots; context tough to corky, white, homogeneous, 4 mm. thick; tubes decurrent, 1 mm. long, mouths 4 per mm., thin-walled, angular, white to pale-isabelline; spores oblong, smooth, hyaline, about $10 \times 3 \mu$; stipe eccentric, solid, woody, equal, minutely velvety, chestnut-black, about 1×0.5 cm.

Type collected by A. S. Rhoads on a dead fallen stem of trembling aspen above Ogden Dam, Weber Co., Utah, Sep. 3, 1944 (*F 19210*).—W. A. MURRILL.

WILLIAM TITUS HORNE

William Titus Horne, Professor of Plant Pathology in the University of California, died on April 12, 1944 in his sixty-seventh year. He was a graduate of the University of Nebraska with a Bachelor of Science degree in 1898. He served as instructor in the Nebraska Wesleyan University and University of Nebraska Farm School. He took graduate study at Columbia University and then served at the Cuban Agricultural Experiment Station as assistant and then chief of the Department of Plant Pathology from 1904 to 1909 where he married Mary Tracy Earle, sister of the late Professor F. S. Earle. He came to the University of California at Berkeley as Assistant Professor of Plant Pathology

in 1909 and was acting Head of the Division of Plant Pathology in 1919-20. He transferred his activities to the Citrus Experiment Station in 1928, where he became Associate Professor and then Professor of Plant Pathology. Here he had a long and useful service especially in the field of avocado and subtropical diseases.

In 1938 he was elected President of the Pacific Division of the American Pathological Society. He was a member of the American Association for Advancement of Science, American Phytopathological Society, California Botanical Society, Torrey Botanical Club, Mycological Society of America, Sigma Xi and Alpha Zeta.

One of his most important publications since coming to Riverside was his 1934 Bulletin on Avocado Diseases. He had ready at his death a completed manuscript on the Diseases of the Guava, which is being edited for publication by the University of California.—H. S. FAWCETT.

David Gruby and the Centenary of Medical Mycology, 1841-1941. Six papers published during the years 1841-1844 constitute the contribution of David Gruby to Medical Mycology. They also form, according to our authors,¹ the very foundation stones of that science. In the first of these papers was described the causative fungus of favus. Later papers announced the discovery of the cause of ringworm of the scalp, ringworm of the beard and thrush. In appropriate recognition of the centenary of their original publication these papers are published for the first time in English translation. The translation and explanatory notes are the work of Dr. Benedek.

On reading these papers, one is impressed by the fact that the author was not only a careful observer but an enthusiastic experimenter. One paragraph from the second paper on favus may be quoted in this connection.

"I carried out," he says, "inoculation on thirty phanerogamic plants; I succeeded only once. On 24 silkworms, I did not obtain any results. On six reptiles, I likewise failed. On four birds and

¹ Zakon, S. J. and T. Benedek. Bulletin of the History of Medicine 16: 155-168. 1944.

on eight mammals, no results. In my first experiment on humans I inoculated Prof. Rinneker, of Wurzburg, on the arm; this inoculation produced a slow inflammation and a slight suppuration. I inoculated myself four times with the same results. In total, in 77 inoculations I obtained a result on one plant only, this unique fact, however, seems to me interesting in giving an example of a human disease communicable to a vegetable."

Introductory to the papers there is a brief sketch of the life of Dr. Gruby (1810-1898), with citations of longer biographies and a portrait. The authors of this article and the editors of the Bulletin of the History of Medicine have done a distinct service in calling attention to this pioneer and in making his contributions readily available in English.—NEIL E. STEVENS.

CYLINDRIC SPORES IN AMANITA

Species of *Amanita* abound in northern temperate regions but all of them have globose, ovoid or ellipsoid spores. In publishing *A. roanokensis* Coker first brought to the attention of mycologists a species with cylindric spores. The second species of this group was described by Beardslee as *A. cylindrispora*. Since then the author has added eight others to the list, all from Florida.

Since the geological history of Florida is recent and there is no indication of the introduction of cylindrosporous forms from tropical America, it is safe to assume that these forms are endemic to Florida and the extension of the coastal plain northward to North Carolina. What appeals to me as of special interest is the fact that this group, obviously of recent origin, has followed the lines of development already so well known in the older species.

In a brief article like this I can only touch upon some of the main points. Take the Verna Group, for example. Here we have the old and widely distributed species, *A. verna*, with globose spores, to which I have added *A. vernella* and *A. suballiacea*. Ellipsoid spores in this group are found in *A. pseudoverna* and *A. verniformis*; while cylindric spores occur in *A. margarita* and *A. tenuifolia*. At first sight, some of these would be referred to *A. verna* without question, but the microscope at once reveals differences.

Several other groups show similar parallels. *A. cylindrispora* has cylindric spores while those of *A. cylindrisporiformis* are ellipsoid. For *A. parva* the counterpart is *A. parviformis*; for *A. praelongispora*, *A. virosa* and *A. virosiformis*, both with ellipsoid spores.

In the large Solitaria Group, so well represented in Florida, the parallel is fully as striking. *A. solitaria*, *A. strobiliformis*, etc. with ellipsoid spores have their perfect counterparts macroscopically in *A. solitariiformis*, *A. Rhoadsii*, etc. with cylindric spores. This is a rich field for observation because biologic groups of recent origin tend to exhibit rapid development and wide variation.

This variation is well illustrated in the odors met with in several Florida species of this genus. Some of them are decidedly strong and persist in the herbarium for years. Others are so unique that it is impossible to describe them. The chemistry of the Florida amanitas must be left to someone with good equipment and plenty of time. I have no doubt that work in this field would prove very absorbing and yield important results.—W. A. MURRILL.

TWO ORTHOGRAPHIC ERRORS IN FUNGOUS NAMES

ALLOMYCES ARBUSCULA Butler.

In a footnote on p. 78 of his monograph of *Allomyces*,¹ Emerson alters the specific epithet of *A. arbuscula* Butler to *arbusculus*, "to agree in gender with the generic name," citing Article 72(2) of the International Rules of Botanical Nomenclature, in which compounds of *-myces* are said to be masculine. *Arbuscula*, however, is not an adjective, but a noun in apposition, meaning "a small tree or shrub," and Butler's binomial was consequently correct. Emerson's variety *arbusculus* (l.c., p. 132) must be written var. *arbuscula*, since it is "a clearly unintentional orthographic error" in the sense of Article 70 of the Rules. Unfortunately the proposed alteration in the specific epithet has been taken up by Sparrow in his Aquatic Phycomycetes, and by others in recent papers, e.g., McCranie (*Mycologia* 34: 212. 1942),

¹ Emerson, Ralph. An experimental study of the life cycles and taxonomy of *Allomyces*. *Lloydia* 4: 77-144. 1941.

Teter (l.c. 36: 194. 1944), and Hatch & Jones (l.c. 36: 369. 1944).

MYIOPHAGUS Thaxter.

On the appearance of Dr. F. K. Sparrow's paper on *Myrophagus*,² I was reminded of a fly-inhabiting chytrid which Thaxter had shown me in 1915; and examination of my notes and drawings made at the time leaves no doubt that they were indeed concerned with the form described by Sparrow. My drawings, however, are unmistakably labelled; in block letters, *Myiophagus*.

Sparrow says that he was shown the fungus by Thaxter in 1927, and speaks of the description as being based in part on his own notes made on that occasion, in part on Thaxter's specimens and camera lucida drawings, now preserved at the Farlow Herbarium. His record of the proposed generic name must have come from his notes of 1927, since Dr. D. H. Linder writes me that no part of the Thaxter material now carries a name.

We have then two alternative interpretations of Thaxterian script, differing by one letter. They may be the variant results of deciphering the label on a slide now lost, or possibly two records of a verbal statement by Thaxter of the name he had selected. The possibility exists also that one of us might be in error in reading his own notes after the lapse of years. However, that can scarcely be the case in respect to the label on my sketches, which is clearly lettered. In such a situation it will be illuminating to consider the meanings which the two spellings produce, in view of Thaxter's well-known skill in aptly designating his novelties.

Myiophagus means "devourer of flies" ($\mu\upsilon\acute{\iota}\alpha$, a fly), an obvious reference to parasitism on a dipterous host. Thaxter named at least two other genera of entomogenous fungi from the same root, *Muigone* and *Muiaria* (Bot. Gaz. 58: 239, 241. 1914), though on that occasion he transliterated the upsilon by *u* rather than *y*. The spelling with *y* is commonly used, however, as in *Myiocopron* Speg. (Microthyriaceae), and *Myiadestes*, *Myiarcus*, and *Myiodiodes*, genera of fly-catching birds. *Myrophagus*, for which no

² Sparrow, F. K., Jr. The entomogenous chytrid *Myrophagus* Thaxter. Mycologia 31: 439-444. 1939.

etymology is given by Sparrow, appears to mean "ointment-eater" (cf. the tuberculariaceous genera *Myropyxis* Ces. and *Myrothecium* Tode), but has no evident application to the form under consideration. There can be no doubt as to which was intended by Thaxter, whose names were nothing if not pat. The possibility that he changed his mind between 1915 and 1927 can be ruled out, since one can be sure that the chytrid would have been quite as well hit off by a new name as by the old.

If the name were Sparrow's, it could be what he chose, and need not, of course, be at all descriptive. Since, however, he clearly intended that it be "placed in a new genus as proposed by Thaxter, and given the name suggested by him" (Sparrow, l.c., p. 443), it becomes necessary to point out that the evidence indicates an orthographic error in the name as published, which should therefore be corrected to *Myiophagus* Thaxter, in conformity with Article 70 of the Rules.—G. SAFFORD TORREY.

